Federal Ministry
for the Environment, Nature Conservation,
Nuclear Safety and Consumer Protection

2024 German Strategy for Adaptation to Climate Change

Shaping precautionary action together

2024 German Strategy for Adaptation to Climate Change

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List of abbreviations

Abbreviation	Explanation
APA	Aktionsplan Anpassung – Adaptation Action Plan
BNB	Bewertungssystem Nachhaltiges Bauen – Assessment System for Sustainable Building
CAP	EU Common Agricultural Policy
CFP	EU Common Fisheries Policy
COP	Conference of the Parties
DAS	Deutsche Anpassungsstrategie an den Klimawandel – German Strategy for Adaptation to Climate Change
ESD	Education for Sustainable Development
EU	European Union
GAK	Gemeinschaftsaufgabe "Verbesserung der Agrarstruktur und des Küstenschutzes" – Joint Task for the Improvement of Agricultural Structures and Coastal Protection
GGA	Global Goal on Adaptation
IACS	EU Integrated Administration and Control System
IMAA	Interministerielle Arbeitsgruppe "Anpassung an den Klimawandel" – Interministerial Working Group on Adaptation to Climate Change
IPCC	Intergovernmental Panel on Climate Change
ISABEL	Informationssystem zur Agrarmeteorologischen Beratung für die Länder – information system for agricultural meteorological advisory services for the federal states
KAnG	Bundes-Klimaanpassungsgesetz – Federal Climate Adaptation Act
KfW	KfW Group
KWRA 2021	Klimawirkungs- und Risikoanalyse 2021 für Deutschland – Climate Impact and Risk Assessment 2021 for Germany
MSY	Maximum Sustainable Yield
NBS 2030	National Biodiversity Strategy 2030
NINA	Notfall-Informations- und Nachrichten-App – Emergency Information and News App
OECD	Organisation for Economic Co-operation and Development
SDGs	UN Sustainable Development Goals
SMEs	Small and medium-sized enterprises
UBA	Umweltbundesamt – German Environment Agency
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UV	Ultraviolet
WFD	Water Framework Directive

Summary

The impacts of climate change in Germany are tangible and quantifiable. In Germany and around the world, 2023 was the hottest year on record since measurements began in 1881; the average temperature in Germany has already risen by 1.8°C (linear trend) since then. The years 2014 to 2023 were already 2.3°C warmer than in 1881. At the same time, Germany has experienced devastating effects from heavy rainfall and flooding in recent years, particularly in 2021 and most recently in 2024. In future, all regions of Germany will be affected by a further rise in temperatures, an increase in the numbers of hot and dry days and a greater risk of heavy rainfall and flooding. Depending on the rate of global warming, the cumulative economic damage is expected to fall into a range of 280 to 900 billion euros by mid-century.

That is why the Federal Government has made adaptation to the impacts of climate change a top priority in the 20th legislative period, alongside ambitious climate action. To tackle this challenge, it has created a new, binding framework for this with the Federal Climate Adaptation Act (Klimaanpassungsgesetz, KAnG). The Act requires the Federal Government, federal states and municipalities to address the impacts of climate change across the board and identify adaptation measures. This new precautionary climate adaptation strategy presented here is the first strategy with measurable targets for adaptation to the impacts of climate change within the scope of responsibilities and competences of the Federal Government, as required by section 3 of the Federal Climate Adaptation Act. As stipulated in section 1 of the Act, the strategy contributes to preserving equivalent living conditions by increasing the resilience and robustness of ecological systems, the economy and society to better withstand the effects of climate change both now and in future.

Section 1 of the strategy highlights the strategy's context and development process and the governance of climate adaptation in Germany. It also puts the German Strategy for Adaptation to Climate Change in the context of national, European and international strategies and goals. Section 2 presents the results of the 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change and the Climate Impact and Risk Assessment 2021 for Germany (KWRA 2021). The measurable targets for climate adaptation, along with the associated indicators and measures that contribute to achieving them, are summarised in section 3 in different cluster categories. In addition to the specific cluster-related targets, the Federal Government addresses other issues relevant to comprehensive precautionary climate adaptation in action areas and fields, which are also outlined in section 3. Section 4 highlights the main mechanisms for guiding and implementing the strategy. Detailed background documents from the ministries for each cluster can be found in Annex 1 (cluster documents, in German) and form the basis for the summary in section 3. Annex 2 (in German) contains the fourth Adaptation Action Plan (APA IV), which provides an overview of the Federal Government's climate adaptation measures. In addition to the measures to achieve the targets set out in the clusters, the APA IV also includes further climate adaptation measures from the federal ministries.

The targets, including the associated indicators, instruments and measures, are divided into various action areas, which are grouped into the following seven clusters: **infrastructure**; **land and land use**; **human health and care provision**; **urban development, spatial planning and civil protection**; **water**; **economy**; and a cluster of **cross-sectoral issues**. The targets address priority areas of climate adaptation that fall within the remit of the Federal Government. They focus primarily on the climate impacts identified in the KWRA 2021 where very urgent action is required. These include climate risks from high temperatures and the change in natural systems and resources, particularly for human health, climate risks from drought, particularly for all systems that use or depend on water, climate risks from heavy rainfall, high water levels, flash flooding and fluvial floods, especially for soil, infrastructure and buildings, as well as climate risks from the gradual rise in temperature and sea levels. Progress towards the targets will be measured by an indicator-based monitoring system.

Cooperation between ministries takes place in the Interministerial Working Group on Adaptation to Climate Change (IMAA), under the lead responsibility of the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection.

The IMAA is supported by the Behördennetzwerk Klimafolgen und Anpassung, a government agency network focusing on climate impacts and adaptation, which is headed up by the German Environment Agency (UBA). This network provides the scientific basis for the strategy documents and reports on the precautionary climate adaptation strategy. Within this framework, 28 higher federal authorities work together on climate adaptation, in particular on monitoring climate impacts and adaptation, as well as on the assessment of risks, policy instruments and measures.

Cooperation within the IMAA also ensures that the climate adaptation strategy is aligned with other strategies of the Federal Government, including the National Water Strategy, the Peatland Protection Strategy, the National Sustainable Development Strategy, the Onshore Wind Energy Strategy and the German Strategy for Strengthening Resilience to Disasters. For the adaptation measures to be implemented effectively, it is essential that all levels of government work not only together but also with non-governmental stakeholders. The federal and federal state governments are working closely together within the framework of the Conference of German Environment Ministers (UMK), the Federal-State Working Group on Climate, Energy, Mobility and Sustainability (BLAG KliNa) and the Standing Committee on Adaptation to the Consequences of Climate Change (StA AFK).

The IMAA developed the precautionary climate adaptation strategy with measurable targets in a broad-based collaborative and participatory process. Representatives of federal states, associations, including municipal umbrella organisations, and the scientific community were extensively involved. At the same time, local residents in five regions of Germany that are affected differently by climate change formulated ideas and recommendations on how to ensure a liveable future despite climate change. The results of the participatory process were reviewed by the cluster-specific interministerial working groups and incorporated into the development of the new climate adaptation strategy.

It is important that the strategy presented here does not create any additional bureaucratic hurdles for individuals or companies. Any additional requirements for human and material resources arising for the Federal Government from the strategy must be fully and continuously funded from the relevant individual ministry budgets or special funds as part of applicable budget and financial planning.

In the **infrastructure** cluster, this strategy deals with two action areas. In the **transport and transport infrastructure** action area, the Federal Government aims to make transport systems more resilient to the impacts of climate change. To this end, transport and logistics conditions on federal waterways must be optimised by 2030-2040 to ensure rivers remain navigable when water levels are low. A further goal is to reduce the number of incidents and disruptions to road and rail transport caused by weather-related factors by 2050. The aim of the **buildings** action area in the **infrastructure** cluster is to adapt buildings and properties to protect users and, in particular, to make existing buildings more resilient by 2030-2050 through precautionary structural measures. This will also help reduce financial risks caused by the impacts of climate change.

The **land and land use cluster** consists of four action areas with closely related targets. In the **biodiversity** action area, the Federal Government aims to minimise the direct and indirect impacts of climate change on biodiversity by 2030. In the **soil** action area, the resilience of soil to the impacts of climate change will be improved, for example, by reducing land take to less than 30 hectares per day by 2030 as well as by reducing new soil sealing. The Federal Government has set two targets under the **agriculture** action area: first, agroecosystems must become resilient to the impacts of climate change; sustainable, locally adapted management and structures must contribute to a diverse range of biotopes and structures, as well as to biodiversity in agricultural landscapes and a climate-resilient land-use system, and to stable production of agricultural raw materials. Second, farms need to become resilient enough to withstand climate variability and adverse weather conditions while also

being able to sustainably produce sufficient high-quality food and animal feed as well as bio-based raw materials, even under challenging climate conditions. The interactions between the **soil** and **agriculture** action areas are dealt with in several joint sub-targets, which address the carbon storage function and soil humus, peat soils, crop diversity, permanent grassland, erosion protection, harmful soil compaction and structural and landscape elements that promote biodiversity. For the **woodlands and forestry** action area, the goal is to achieve climate-resilient and locally adapted forests and adaptive, near-natural and sustainable forest management, making forests adaptable to climate change and resilient to climate variability and adverse weather conditions, and to ensure favourable conditions for the preservation of their functionality through their high biodiversity.

In the **human health and care provision** cluster, the Federal Government aims to strengthen the public's ability to adapt to heat and ultraviolet exposure by 2030. This approach will improve both individual behaviour and preventative structures, in other words the general conditions in municipalities and health and care facilities. A further goal is to strengthen the public's ability to deal with pollen allergies and prevent infectious diseases facilitated by climate change, particularly vector-borne diseases (whose pathogens are transmitted by vectors such as mosquitoes or ticks) by 2030.

The **urban development, spatial planning and civil protection** cluster is comprised of three action areas. One of the targets in the **urban and settlement development** action area is to activate urban green spaces to reduce heat stress. Furthermore, the aim is to work towards a near-natural water balance for water-smart urban development to minimise the risks posed by heavy rainfall and drought, as well as to activate evaporation cooling. In the **spatial planning** action area, the Federal Government aims to develop and introduce climate adaptation monitoring (ex-post) for spatial development plans at the federal state and regional level by 2026, and to improve how future climate change impacts are taken into account when drawing up and updating spatial plans at the federal state and regional level by 2028. The **civil protection and disaster response** action area comprises three further targets in this cluster: to expand the reach of warnings to the general public and increase the level of public information and preparedness on the risks associated with climate change, in particular extreme weather events. Furthermore, the aim is to raise the visibility and attractiveness of volunteering in civil protection.

In the **water** cluster, the action areas of **water balance and water management, including flood risk, low water risk and rainstorm risk management, coastal and marine protection** and **fisheries** are addressed in three joint targets. The first aim is to continue to ensure a sufficient supply of high-quality water for humans and nature, and for people's social and economic activities. The second aim is to strengthen the resilience of the water infrastructure. The goal is to design infrastructure that can be adapted with as little effort as possible to evolving conditions such as climate change, new demands from the public for higher ecological standards or the changing water needs of users. Wherever possible, infrastructure design will incorporate nature-based solutions, harnessing the potential of interconnected water, energy and material cycles and networked at the appropriate intermunicipal level. The third target concerns the ecology of water bodies and aims to promote climate-resilient bodies of water, for example by improving and restoring the near-natural state of water body structures and stabilising water temperatures. For the fisheries action area, the aim under European legislation is to manage all fish stocks sustainably at levels that produce the maximum sustainable yield.

In the **economy** cluster, the Federal Government aims to establish a climate-resilient economy over the medium term. This means that all economically relevant decisions will take the impacts of climate change into strategic consideration, and all stakeholders at all levels will ensure comprehensive adaptation to the unavoidable impacts of climate change. Analysing the physical climate risks will need to become an integral part of risk management and corporate investment decisions. Another target is to ensure that extreme weather events no longer lead to significant losses due to their impacts on staff and corporate assets of companies in Germany. Furthermore, German companies must be able to operate successfully on national and international markets with

climate adaptation technologies and services and continuously increase their aggregated added value in line with the trend.

The **cross-sectoral action area** cluster addresses systemic needs for action and the general conditions for precautionary climate adaptation. In the area of municipal adaptation planning, the target is for climate adaptation plans to be in place for 80 percent of the municipalities and districts required to do so by the federal states by 2030 under section 12 (1) of the Federal Climate Adaptation Act. In addition, the Federal Government plans to survey federal expenditure on climate adaptation every two years starting in 2026 and to collect data on the financial losses due to damage caused by extreme weather events. In addition, the natural hazards portal of the German Weather Service will be set up as a central information source to make this data available to the public. In the area of research, the aim is faster implementation of research findings on climate adaptation by involving more users of this research as partners in projects and by increasing the number of practitioners in research projects by 20 percentage points by 2040 (reference period: 2022 to 2024). In addition, at least 20 research-based products will be established in practice by 2030. Furthermore, the Federal Government will establish a national framework with indicators and measures so that the UNESCO World Heritage sites in Germany can develop climate change mitigation measures and/or climate adaptation strategies or plans by 2030. To adapt federal properties to climate change, the Federal Government aims to present land management plans for 100,000 hectares of federal forest land by 2033, with climate adaptation measures in the form of forest management plans. By 2027, it also intends to conduct inspections of all civilian properties to determine their capacity to withstand heavy rainfall.

In addition to the specific cluster-related targets, the Federal Government will address other issues relevant to comprehensive precautionary climate action in a number of action fields for which targets could be developed in future. The action fields include social justice and vulnerable groups, occupational health and safety, the provision of basic digital data, personal and financial preparedness, education and sport.

The targets and measures set out for the first time in this strategy will be reviewed every four years and, if necessary, further developed or adapted. The next strategy monitoring report is scheduled for publication in 2027, and will serve as the basis for the Federal Government's first assessment of progress towards the targets. In 2028, an updated climate risk analysis will also be presented as a basis for further strategy development. It will examine the possible future impacts of climate change in Germany, assess the associated climate risks, identify the areas where action is urgently needed and estimate the effectiveness of adaptation options for risk mitigation. Both products – the strategy monitoring report and the climate risk analysis – essentially form the basis for updating this strategy.

1 Introduction

1.1 Strategy context

How climate change is affecting Germany

The impacts of climate change in Germany are tangible and quantifiable. In Germany and around the world, 2023 was the hottest year on record since measurements began in 1881; the average temperature in Germany has already risen by 1.8°C (linear trend) since then.[1] In Germany, the past ten years (2014-2023) were 2.3°C warmer than when measurements first began. Between 2018 and 2022, severe droughts occurred in many regions, resulting in crop losses, damage to forests and conflicts over water use. At the same time, Germany has experienced devastating effects from heavy rainfall and flooding in recent years, particularly in 2021 and most recently in 2024.[2]

In future, all regions of Germany will be affected by a further rise in temperatures, an increase in the numbers of hot and dry days and a greater risk of heavy rainfall events. Coastal regions are also vulnerable to the dangers of accelerated sea level rise, and rivers will be more likely to flood as a result of climate change. Droughts and phases of low water levels can have serious large-scale economic and environmental impacts.

The damage caused by extreme weather events in Germany between 2000 and 2021 is estimated to be at least 145 billion euros. Depending on the rate of global warming, the cumulative economic damage is expected to reach between 280 and 900 billion euros by mid-century. In addition to the financially quantifiable damage, there are many negative effects on health, deaths due to heat and flooding, harm to ecosystems, biodiversity loss and a lower quality of life.[3]

Climate adaptation: a key challenge

This situation has led the Federal Government to make adaptation to the impacts of climate change a top priority in the 20th legislative period, alongside ambitious climate action. It has created new, binding foundations to tackle this challenge. In December 2023, the first Federal Climate Adaptation Act was adopted, establishing a binding framework for climate adaptation at federal, federal state and municipal level. The Act requires the Federal Government, federal states and municipalities to address the impacts of climate change across the board and identify adaptation measures. A consideration requirement stipulates that all other bodies discharging public functions take due consideration of climate adaptation in their planning and decision-making on a cross-disciplinary and integrated basis.

This new precautionary climate adaptation strategy is the first strategy with measurable targets for adaptation to the impacts of climate change within the scope of responsibilities and competences of the Federal Government, as required by section 3 of the Federal Climate Adaptation Act. This is intended to enable a coordinated approach that will make the Federal Government's measures more transparent and more effective, and identify any need for corrective action at an early stage.

The goal is to help prevent negative impacts of climate change, in particular the impending damage or, so far as they cannot be prevented, to minimise them to protect life and human health, society,

[1] German Meteorological Service (2024): Klimastatusbericht 2023.
https://www.dwd.de/DE/leistungen/klimastatusbericht/publikationen/ksb_2023.html.
[2] German Environment Agency (2023): 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change.
https://www.umweltbundesamt.de/publikationen/2023-monitoring-report-on-the-german-strategy-for
[3] Federal Ministry for Economic Affairs and Climate Action (2023): Kosten durch Klimawandelfolgen in Deutschland.
https://www.bmwk.de/Redaktion/DE/Artikel/Klimaschutz/kosten-klimawandelfolgen-indeutschland.html.

the economy, infrastructure and nature and ecosystems (see section 1 of the Federal Climate Adaptation Act).

This strategy builds on the broad scientific foundations of the 2008 German Strategy for Adaptation to Climate Change and the related 2015 and 2020 progress reports and goes one important step further by focusing on specific, measurable targets. The Federal Government has broken new ground by formulating adaptation targets. The aim is to use concrete, measurable targets to make climate adaptation in Germany more efficient and transparent and to enable corrective action where necessary. Quantifying targets in the various climate adaptation action areas is complex and challenging from a technical perspective as there is no standardised benchmark or indicator such as CO2 equivalents, which are used for climate change mitigation. In some cases, it is only possible to measure progress after a certain period of time because measures, for example for urban planning or forest conversion, may only take effect much further down the line. Climate adaptation measures are also very context-specific.

The targets and corresponding measures are therefore reviewed and updated every four years and, if necessary, further developed. In some cases, new indicators for measuring progress need to be developed and further substantiated, and in other cases, new basic data need to be created.

The targets contained in this strategy prioritise those targets that the Federal Government can help achieve within its current area of responsibility. Other targets that have not yet been formulated can be pursued simultaneously and supplemented in the planned updates. For climate adaptation in Germany to be successful, different stakeholders need to work together at all levels of government and in all action areas as a shared undertaking, with the involvement of the public and businesses. For this reason, this strategy is also intended to encourage other stakeholders to set relevant targets for their respective areas that can contribute to joint climate action in future.

Empowering stakeholders to adapt to climate change will play a key role in this context. For the Federal Government, one of the key starting points is the promotion of research and innovation. It provides support in this area through data services, underlying scientific work and research projects (see section 9 of the Federal Climate Adaptation Act). Promoting climate adaptation research as part (specifically Mission 2) of the Federal Government's Future Strategy for Research and Innovation will help develop suitable and up-to-date methods and data for the design of climate adaptation measures and facilitate and accelerate their implementation.

Scope of the strategy

The targets, including the associated indicators, instruments and measures, are divided into seven clusters: **infrastructure**; **land and land use**; **human health and care provision**; **urban development, spatial planning and civil protection**; **water**; **economy**; and a cluster with **cross-sectoral** action areas including municipal climate adaptation planning, expenditure and damage assessment, research on climate adaptation, cultural and natural heritage and climate-adapted federal properties. The targets of the clusters address priority areas of climate adaptation that fall within the remit of the Federal Government. They focus primarily on the climate impacts identified in the Climate Impact and Risk Assessment 2021 for Germany (Klimawirkungs- und Risikoanalyse für Deutschland 2021, KWRA 2021)[4] that require particularly urgent action.

Progress towards the targets will be measured by an indicator-based monitoring system (see section 4.1). In addition, the fourth Adaptation Action Plan (APA IV), as part of the precautionary climate adaptation strategy, summarises further climate adaptation instruments and measures of the

[4] German Environment Agency (2021): Climate Impact and Risk Assessment 2021 for Germany. https://www.umweltbundesamt.de/publikationen/KWRA-English-Summary

Federal Government that go beyond the specific targets. These additional instruments and measures are an expression of the fact that, in addition to the climate risks addressed by the targets in the clusters, other action areas often need to be adapted to climate change. Together with the measures for achieving the targets, they complete the Federal Government's Adaptation Action Plan IV for climate adaptation. The Federal Government already reported on the activities of the ministries in 2011 and in the 2015 and 2020 progress reports with the Adaptation Action Plans I-III (APA I-III). The new APA IV follows this format.

It is important that the indicators presented here do not create any additional bureaucratic hurdles or reporting requirements for individuals or companies.

A budgetary and constitutional proviso applies: including targets in the strategy does not change the fact that the funding needed to achieve them must conform to the Federal Government's budgetary and financial constraints. The measures outlined or arising from the strategy form the basis for the internal financial priorities set for the ministry. They are subject to funding provisos and existing administrative or funding powers of the Federal Government. They do not contain a (pre-)determination with regard to the budget, nor do they prejudice the budget legislator. Any additional requirements for human and material resources arising for the Federal Government from the strategy must be fully funded for the long term from the relevant individual ministry budgets or special funds as part of applicable budget and financial planning. To this end, synergies should be identified and leveraged when it comes to human and material resources.

1.2 Governance and reporting on the precautionary climate adaptation strategy

The central components and reports associated with climate adaptation planning in Germany are set out by law in the Federal Climate Adaptation Act (see also section 4). Climate adaptation in Germany is a long-term endeavour that is guided by a politically agreed legal, institutional and methodological framework. It is enshrined in all sectoral policies and therefore in every federal ministry.

Cooperation between ministries takes place in the Interministerial Working Group on Adaptation to Climate Change (IMAA), under the lead responsibility of the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection. All federal ministries work together in the IMAA, regularly coordinating their activities, targets and measures to avoid conflicting goals in climate adaptation and to harness synergies. Cooperation within the IMAA also ensures that the adaptation strategy is aligned with other relevant strategies of the Federal Government. The goals and targets of these strategies, which include the National Water Strategy, the National Sustainable Development Strategy, the German Strategy for Strengthening Resilience to Disasters and the Onshore Wind Energy Strategy, are not affected by the Climate Adaptation Strategy.

The IMAA also ensures that information is shared with other interministerial working groups, such as the Interministerial Working Group for the Sendai Framework for Disaster Risk Reduction and the Interministerial Working Group on Heat Protection.

The IMAA is supported by the Behördennetzwerk Klimafolgen und Anpassung, a government agency network focusing on climate impacts and adaptation. This network provides the scientific basis for the strategy documents and reports on the precautionary climate adaptation strategy. Coordinated by the German Environment Agency, 28 higher federal authorities are working together on climate adaptation, in particular on monitoring climate impacts and adaptation, the assessment of climate risks and new and future policy instruments and suitable measures.

For the climate adaptation measures to be implemented effectively, it is essential that all levels of government work together. The federal and federal state governments are working closely together

within the framework of the Conference of German Environment Ministers, the Federal-State Working Groups on Climate, Energy, Mobility and Sustainability and on Water (German Working Group on water issues of the Federal States and the Federal Government, especially the group dedicated to climate) and the Standing Committee on Adaptation to the Consequences of Climate Change. At municipal level, there is regular dialogue between the Federal Environment Ministry and municipal umbrella organisations.

In addition, the Federal Environment Ministry supports municipalities and social institutions through the Centre for Climate Adaptation (Zentrum KlimaAnpassung, ZKA), which provides advice on planning and implementing climate adaptation strategies and measures. Relevant basic data for adaptation, such as changes in meteorological, hydrological or oceanographic parameters, are provided, for example, by the German Meteorological Service (DWD) and the operational DAS Climate and Water Data Service provided by the Federal Ministry for Digital and Transport. Furthermore, various regional activities, such as the regional conferences of the federal states, contribute to knowledge sharing, networking and cooperation at sub-national level.

1.3 Participatory process for strategy development

The IMAA developed the precautionary climate adaptation strategy with measurable targets in a broad-based collaborative and participatory process. The focus was on developing measurable targets, indicators, instruments and measures in the seven clusters. In autumn 2023, the Federal Environment Ministry and the German Environment Agency organised a broad-based dialogue with stakeholders and the public called Dialogue Climate Adaptation, Managing Life in Climate Change Together. The recommendations of the national participatory process were summarised in a document and published.[5]

Stakeholders were involved at an early stage in drawing up a first rough draft of measurable targets, indicators and measures for a precautionary climate adaptation strategy in December 2023. Representatives of federal states, associations, including municipal umbrella organisations, and the scientific community were involved both in a two-day stakeholder dialogue and in an online consultation.

Public participation took place in five dialogue events, to which the Federal Environment Ministry and the German Environment Agency invited randomly selected people from regions affected to varying degrees by climate change: the Baltic Sea coast in Wismar, the Middle Elbe in Dessau-Roßlau, the Rhine-Ruhr in Duisburg, the Rhine-Main in Worms and the Bavarian Forest in Zwiesel.

Over two days, a total of 331 people developed ideas and recommendations on how to shape a liveable future despite climate change. The public recommendations for the development of a precautionary climate adaptation strategy[6] were summarised and expanded with the support of regional delegates to include cross-regional core messages. In addition, around 2,000 people across Germany participated through an online dialogue platform of the Federal Environment Ministry.[7] Young people between the ages of 14 and 25 were surveyed separately online. Participation focused on questions about the everyday perceptions of climate impacts, personal preparedness, further need for action and responsibilities, as well as expectations and fears about the future, particularly

[5] German Environment Agency (2024): Empfehlungen aus dem Dialog KlimaAnpassung – Beteiligungsprozess zur Entwicklung messbarer Ziele für die Deutsche Klimaanpassungsstrategie. https://www.umweltbundesamt.de/publikationen/empfehlungen-aus-dem-dialog-klimaanpassung.

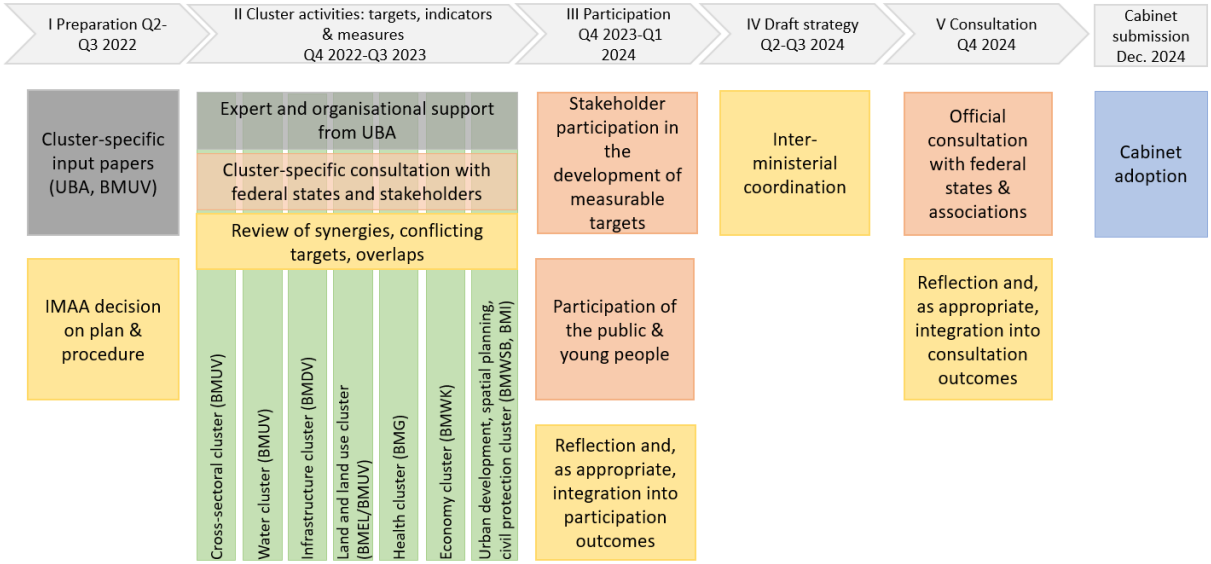
[6] German Environment Agency (2024): Empfehlungen von Bürgerinnen und Bürgern für die Entwicklung einer vorsorgenden Klimaanpassungsstrategie. https://www.umweltbundesamt.de/publikationen/empfehlungen-von-buergerinnen-buergern-fuer-die.

[7] German Environment Agency (2024): Ergebnisse der bundesweiten Online-Beteiligung von Bürgerinnen und Bürgern für die Entwicklung einer vorsorgenden Klimaanpassungsstrategie.

among the younger generation. The results of the participatory process with the public and stakeholders were reviewed by the cluster-specific interministerial working groups and incorporated into the development of the new climate adaptation strategy.

The draft of the precautionary climate adaptation strategy, coordinated across ministries, was subject to final formal consultations with the federal states and associations in October 2024. A lot of very valuable and constructive comments and responses were received. These were reviewed by the ministries responsible for the clusters, discussed in an interministerial exchange in November 2024 and, where possible, taken into account in the draft strategy. Comments that could not be directly incorporated into the strategy text can still be taken into account in the further process of both implementing and updating the strategy. This also includes the development of further indicators and targets.

Figure 1: Process for developing measurable targets for a precautionary climate adaptation strategy



1.4 2024 German Strategy for Adaptation to Climate Change in the context of European and international climate adaptation strategies and goals

The political process for climate adaptation in Germany is embedded in European and international strategy processes. After all, people, ecosystems and infrastructure are increasingly at risk from climate-related hazards that can cause loss and damage all over the world, not just in Germany.

The countries and people who are already most vulnerable due to a number of factors are being particularly hard hit by the impacts of climate change. They have few defences against this added impact. At the same time, however, only a comprehensive and proactive approach to the various risks can ensure sustainable development and prevent backtracking on progress that has already been made. Climate adaptation policy in Germany is inextricably linked to European and international responses to the impacts of global warming.

Germany is actively contributing to climate adaptation activities and to efforts to tackle climate-related loss and damage at international and European level under the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement. The Paris Agreement established climate adaptation and climate change mitigation as equally important pillars of international climate policy. Article 7 defines a Global Goal on Adaptation (GGA) for the first time, aimed at “enhancing [the world’s] adaptive capacity, strengthening resilience and reducing vulnerability to climate

change". At COP28 in Dubai, the UAE Framework for Global Climate Resilience[8]) was adopted to review overall progress towards the GGA and provide better support for adaptation efforts. Despite the different degrees of abstraction at the various levels, there are some overlaps in issues covered by the goals of the framework and the clusters outlined in this strategy. Germany plays a leading role in these international climate adaptation negotiations.

At the 2015 UN Climate Change Conference in Paris, it was also agreed that the industrialised countries would continue to provide the 100 billion US dollars per year in climate financing from public and private sources for developing countries by 2025, as agreed at the 2009 UN Climate Change Conference in Copenhagen. In addition to bilateral cooperation, Germany fulfils its international responsibility by contributing to multilateral channels, such as multilateral development banks or funds under and outside the UNFCCC and the Paris Agreement. These include the Green Climate Fund (GCF) and the Adaptation Fund (AF), where Germany is currently the largest donor, as well as the International Climate Initiative (IKI), the Special Climate Change Fund (SCCF), the Least Developed Countries Fund (LDCF), the Strategic Climate Fund (SCF) and the Global Environment Facility (GEF).

In 2015, the Sendai Framework for Disaster Risk Reduction (SFDRR) and the 2030 Agenda for Sustainable Development, including the Sustainable Development Goals (SDGs), were adopted at UN level, underscoring the importance of climate adaptation. Climate adaptation also plays a key role in the Federal Government's National Security Strategy (2023) and its Strategy on Climate Foreign Policy (2023), as both strategies identify climate risks as drivers of conflict that are already having a significant impact on security and foreign policy. This includes exacerbating inequalities due to increasingly scarce resources, hunger and other humanitarian crises, which often lead to more refugees and migration. The strategies mentioned are designed to prevent these climate-related escalations of conflict. Furthermore, adaptation to climate change has also become increasingly important in international organisations such as the Organisation for Economic Co-operation and Development (OECD) and in the context of G7 and G20 meetings.

Germany also promotes networking with international and European partners and the European Union, in part through its involvement in various networks, working groups and committees, such as the EPA Network (Network of the Heads of European Environment Protection Agencies), the European Environment Information and Observation Network (EIONET) and the Working Group on Adaptation (WGA) of the European Commission, in drawing up reports of the Intergovernmental Panel on Climate Change (IPCC) Working Group 2 and the OECD Climate Change Expert Group (CCXG).

At European level, climate adaptation is integrated into the framework of the European Green Deal. The EU Adaptation Strategy,[9] published in the context of the European Green Deal in 2021, aims to deliver smarter, faster and more systemic adaptation action and to strengthen climate adaptation measures internationally. The European Climate Law,[10] which was also adopted in 2021, stipulates that the relevant EU institutions and the Member States must ensure continuous progress in terms of adaptive capacity, strengthening resilience and reducing vulnerability to climate change. To this end, the Member States need to develop and implement national adaptation strategies and plans. The Commission published recommendations on how to design these national plans in 2023, which also

[8] UAE stands for United Arab Emirates.
[9] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Forging a climate-resilient Europe - the new EU Strategy on Adaptation to Climate Change, COM(2021) 82 final. eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX%3A52021DC0082
[10] Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ("European Climate Law"). https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX%3A32021R1119.

contributed to the strategy set out here.[11] Reports on the progress of the EU as a whole and on national progress are submitted on a regular basis and evaluated by the Commission. The first European Climate Risk Assessment (EUCRA), published in 2024, establishes a common understanding at EU level of the risks posed by climate change and highlights how urgently action is needed. In addition, the Commission has created a new instrument – the EU Mission on Adaptation to Climate Change – to enable far-reaching, systemic change towards adaptation by 2030. The mission is part of the Horizon Europe research and innovation programme, but its scope extends well beyond research and innovation. It focuses on the use of innovative solutions for climate resilience on a large scale. Since August 2020, the Commission Implementing Regulation on climate adaptation reporting[12] has been in place to meet the reporting requirements specified in the Governance Regulation and the United Nations Framework Convention on Climate Change. In addition, the UNFCCC requires further reporting in the form of National Communications (every four years) and Biennial Transparency Reports (every two years). The reporting requirements at the various levels (national, EU, UN level) need to be aligned as closely as possible.

[11] Guidelines on Member States' adaptation strategies and plans. https://climate.ec.europa.eu/system/files/2023-07/Guidelines%20on%20MS%20adaptation%20strategies%20and%20plans.pdf.

[12] Commission Implementing Regulation (EU) 2020/1208 of 7 August 2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) No 749/2014. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX%3A32020R1208&from=EN

2 Analysis

2.1 Current impacts of climate change in Germany

The Monitoring Report on the German Strategy for Adaptation to Climate Change, which is published every four years, outlines the impacts of climate change and how they affect various action areas. This report also forms the scientific basis for evaluating progress in achieving the targets and for updating the climate adaptation strategy in accordance with the provisions of the Federal Climate Adaptation Act.

The 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change[13] shows that Germany has faced recurring and unprecedented heat waves, droughts, flash flooding and flooding over the past decade. The annual mean air temperature in Germany has been statistically proven to have risen by 1.8°C (linear trend) between 1881 and 2023, while the past ten years from 2014 to 2023 were already 2.3°C warmer than when measurements began.[14] [15] For the period 1881 to 2018, the value was 1.5°C. 2018, 2020, 2022 and 2023 were the warmest years in Germany on record. There has been a trend in the past few decades towards ever greater extremes of heat. In particular, there has been a significant increase in the number of "hot days" when the highest daily temperature is 30°C or above. Summers with severe heat waves and new maximum air temperature records are becoming more common; for example, in July 2022, a temperature of over 40°C was measured for the first time in Europe north of the 53rd parallel at the Hamburg-Neuwiedenthal station.[16] The hot periods particularly affected people in large cities.[17] In Berlin, Frankfurt am Main and Munich, for example, hot days with maximum daily temperatures of at least 30°C and tropical nights, when temperatures did not drop below 20°C, occurred significantly more often than the national average for Germany. The differences are particularly striking in years with above-average summer temperatures. While the national average for the record-breaking heat wave year of 2018 was 20.4 hot days, Frankfurt am Main recorded 42. Heat has significant impacts on human health and well-being, especially for vulnerable groups – according to the Robert Koch Institute (RKI), around 4,500 heat-related deaths were recorded in Germany in summer 2022 and 3,200 in summer 2023.[18]

The frequency and severity of extreme weather events increased during the reporting period of the 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change (up to and including 2022). Air, water and ground temperatures continued to rise, intensifying the impacts on the environment, people, infrastructure and the economy. Some of the past years were also marked by low levels of precipitation, which, in combination with high temperatures, led to severe droughts in some regions. From 2018 to 2020, Germany's renewable water resources were well below average at just 116 to 135 cubic kilometres (1991-2020: 176 cubic kilometres). [19] Since 2000, Germany has lost an average of 2.5 cubic kilometres of water per year.[20] Between 2019 and 2021, monitoring

[13] German Environment Agency (2023): 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change. https://www.umweltbundesamt.de/en/publikationen/2023-monitoring-report-on-the-german-strategy-for.
[14] German Meteorological Service (2024): Klimatologischer Rückblick auf 2023. https://www.dwd.de/DE/leistungen/besondereereignisse/temperatur/20240201_klimarueckblick-2023.pdf.
[15] In Germany, the temperature increase during the same period is around 0.6°C higher than globally (1.18°C in 2023, see NOAA (2024). https://www.ncei.noaa.gov/access/monitoring/monthly-report/global/202313). The reason is that terrestrial regions warm up more quickly than marine regions. Background information on temperature trends can be found in the 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change.
[16] German Environment Agency (2023): 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change. https://www.umweltbundesamt.de/en/publikationen/2023-monitoring-report-on-the-german-strategy-for.
[17] 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change, indicator BAU-I-1 Heat stress in urban areas.
[18] 2023: https://www.rki.de/DE/Content/GesundAZ/H/Hitzefolgekrankheiten/Bericht_Hitzemortalitaet.html. 2022: https://www.rki.de/DE/Content/Infekt/EpidBull/Archiv/2023/26/Art_02.html.
[19] https://www.umweltbundesamt.de/daten/wasser/wasserressourcen-ihre-nutzung#die-wasserressourcen-deutschlands.
[20] 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change, indicator WW-I-1 Terrestrially stored water.

stations in a number of places recorded the lowest groundwater levels in many years.[21] The effects of the years of drought had been partially compensated for again in many federal states as of mid-2024.[22]

Inadequate water availability in the soil[23] led to a decline in agricultural yields. In 2018, a very hot and dry year, winter wheat yields were 15 percent lower and silage maize yields 20 percent lower than the average of the six previous years[24]. In Germany, forest conditions have significantly deteriorated due to drought stress and the associated beetle infestation[25]. Since 2018, tree mortality rates have gone up for all tree species. The 2020 Forest Condition Survey indicates a record high. Twenty times as many spruce trees died than the average for the previous ten years (2010-2019). Deciduous tree species such as beech and oak are also affected by drought stress and, as a result, by disease complexes. Furthermore, the losses affect not only individual trees, but entire forest stands.[26] Since 2018, over half a million hectares have been affected by a mass infestation of bark beetles and the effects of drought to such an extent that these forests need to be rejuvenated. The extremely dry weather conditions of these years were also clearly evident in the forest fire situation. There were more forest fires, and in the north-eastern federal states they also affected larger areas,[27] in part because the fire brigade were hampered in their efforts to fight these fires due to contaminated military sites.

Higher environmental temperatures and the decrease in water levels have measurable ecological impacts: for example, warmer seas[28] are causing the habitats of fish species to shift northwards. In the North Sea, native species are moving into Nordic waters and species from more southerly waters are taking their place.[29] In the Baltic Sea, rising water temperatures are disrupting food chains. In August 2022, the Oder River experienced an environmental disaster with a mass die-off of fish, snails and mussels. This resulted from a combination of stress factors: the Oder River had little water due to the drought, and the water temperature was high. The discharge of salts led to a massive increase in the population of the brackish-water algae *Prymnesium parvum*, which produces a toxic substance that can be fatal for fish and other aquatic organisms.[30]

Higher temperatures also lead to a change in the species composition of land-based ecosystems. This is evidenced, for example, by data on the species composition of birds[31] and butterflies.[32] The arrival of new species from warmer regions can also have health consequences for humans. For example, we are seeing an increase in the establishment of potential carriers of pathogens, as shown in the 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change using the example of the tiger mosquito.[33]

[21] 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change, indicator WW-I-2 Groundwater level and spring flow.
[22] GRUVO, https://gruvo.bgr.de/website/monat.
[23] 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change, indicator BO-I-1 Soil water in agriculturally used soils.
[24] 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change, indicator LW-I-2 Yield fluctuations.
[25] 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change, indicator FW-I-3 Forest condition.
[26] 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change, indicator FW-I-4 Dieback rate.
[27] 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change, indicator FW-I-8 Forest fire hazards and forest fires.
[28] 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change, indicator KM-I-1 Water temperature in the sea.
[29] 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change, indicator FI-I-1 Distribution of thermophilic marine species.
[30] 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change, indicator FI-I-2 Herring larvae in the Greifswalder Bodden.
[31] 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change, indicator BD-I-2 Temperature index for bird species communities.
[32] 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change, indicator BD-I-3 Temperature index of butterfly species communities.
[33] 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change, indicator GE-I-5 Pathogen vectors (case study).

Heat waves and dry periods have led to limited functionality of the transport infrastructure. For example, freight transport was hampered by technical problems,[34] due to low water levels, coal deliveries by ship were limited, which in turn restricted electricity production in thermal power plants in Germany and in other countries connected to the European electricity grid. Overall, low water levels led to a measurable slowdown in economic activity in Germany in 2018.[35] Weather conditions also led to some restrictions in passenger transport.[36] In this case, transport and logistics must be adapted to extreme weather and low water levels.

However, in recent years some regions have also experienced extreme flooding, with the long-term average flood runoff being exceeded many times over at some measuring points[37]. The seeming contradiction between a water shortage (hydrological drought) and extreme flooding actually reflects a causal relationship that occurs when the climate gets warmer: warmer air absorbs more moisture, which increases the risk of heavy rainfall on the one hand, while dry periods become more frequent on the other. During heavy rainfall, the dried-out soils are unable to absorb and store the water, causing rainwater to run off over the surface and rapidly increase the water levels in rivers, causing them to burst their banks.

It is the extreme events that are most vividly etched in our collective memory: from 12 to 15 July 2021, the low-pressure system Bernd brought extreme rainfall to various parts of western Europe. In the region around the Ahr and Erft rivers in the federal states of Rhineland-Palatinate and North Rhine-Westphalia, flash flooding and fluvial floods caused catastrophic damage and losses, with over 180 deaths in Germany, most of them in the Ahr Valley. The highest overall claims expenditure for property insurance to date were for damage caused by natural hazards[38] to residential buildings, household possessions and businesses, amounting to 8.1 billion euros. The Gesamtverband der Deutschen Versicherungswirtschaft e.V., the German Insurance Association, estimates the insured damage to houses, household possessions, businesses and motor vehicles at 4.9 billion euros for 2023, which corresponds to the long-term national average.[39] Between November 2023 and June 2024, Germany experienced several floods that, depending on the region, can be described as extreme in terms of their duration (for example Weser, Aller), the speed of the rising water and also the peak level (Danube).[40]

2.2 Future climate risks in Germany

The Federal Government produces a climate risk assessment at least every eight years. It analyses the possible future impacts of climate change in Germany, assesses the associated climate risks and evaluates the need for action and the effectiveness of potential adaptation measures to mitigate risk. Section 4 of the Federal Climate Adaptation Act sets out the central role of the climate risk analysis as the scientific basis for climate adaptation planning at federal level and for the derivation and further development of adaptation targets for climate adaptation planning in Germany.

[34] 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change, indicator VE-I-2 Low-water restrictions to shipping on the Rhine.
[35] https://www.wirtschaftsdienst.eu/inhalt/jahr/2019/heft/1/beitrag/niedrigwasser-bremst-produktion.html.
[36] 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change, indicator VE-I-6 Weather-related disruptions to the railway infrastructure.
[37] 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change, indicator WW-I-5 Peak discharge values in watercourses.
[38] 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change, indicator BAU-I-5 Claims expenditure for property insurance.
[39] Naturgefahrenbilanz 2023: 4,9 Milliarden Euro Schäden durch Wetterextreme (gdv.de).
[40] Danube up to about HQ50, smaller tributaries up to HQ>100; https://www.bafg.de/DE/5_Informiert/4_Infothek/Aktuelles/_doc/2024/240610_HW-Bericht1.pdf.

The results of the current KWRA 2021 show that all life forms and systems in Germany are affected by climate change, but to different degrees in different places and at different times.[41]

The KWRA 2021 is based on two possible future scenarios, one for the middle of the century (2031 to 2060) and one for the end of the century (2071 to 2100). Based on forecasts from the Intergovernmental Panel on Climate Change (IPCC 2014), the KWRA 2021 analyses a pessimistic case (hereinafter referred to as strong climate change; including an increase in the annual mean temperature in Germany of +3°C by the middle of the century compared to the early industrial period (1881 to 1910)) and a more optimistic case (hereinafter referred to as weaker climate change; including an increase in the annual mean temperature in Germany of +2.4°C by mid-century).[42] Where possible, the climate forecasts were combined with forecasts of socio-economic data (up to the year 2045, covering population growth, population density and urbanisation) to provide the best possible estimate of future impacts.

In the KWRA 2021, over 100 climate-related impacts – categorised into 13 action fields of the German Strategy for Adaptation to Climate Change – were analysed and assessed in terms of the level of associated climate risk. For selected impacts, the study considered the extent to which and how quickly adaptation can mitigate climate risk. The study distinguished between the measures already adopted and more far-reaching adaptation measures. The measures listed in the last federal Adaptation Action Plan (APA III), which is part of the second progress report on the German Strategy for Adaptation to Climate Change, were used as the climate adaptation measures already adopted. The KWRA 2021 described measures that go beyond those already adopted and that can be implemented under current conditions as more far-reaching adaptation measures taken from the relevant literature and evaluated by the network of authorities. Comparing climate risks with and without adaptation made it possible to identify and characterise the need for action.

By mid-century, the climate risks may already be considerable, especially in the event of strong climate change and assuming that no further adaptation measures are implemented by that time (climate risks without adaptation, see Figure 2). Depending on the efforts made to mitigate climate change, there may be a very significant increase in climate-related changes around the world by the end of the century, at the expense of future generations.

In particular, natural systems and resources (for example, soil, water, species, aquatic and terrestrial ecosystems) and the economic systems that use nature and depend directly on natural resources (for example, fisheries, agriculture, forestry and water management) could be severely affected by as early as the middle of the century. The reasons for this include far too little water in the soil, a change in groundwater recharge, a change in how water is distributed in groundwater and surface waters, a deterioration in the water quality of the seas, oceans and inland waters, increased soil erosion, a shift in the regions where crops are grown, a change in the range of species and varieties, damage to ecosystems such as forests, wetlands, mountains and coasts, and the emergence of new pests and plant diseases.

Natural systems and resources are the basis for fishing, agriculture, forestry and water management, as well as for many forms of human recreation. To prevent negative ripple effects on economic systems and human health and to enable sustainable forms of use, the conservation and adaptation of natural systems and resources is particularly important.

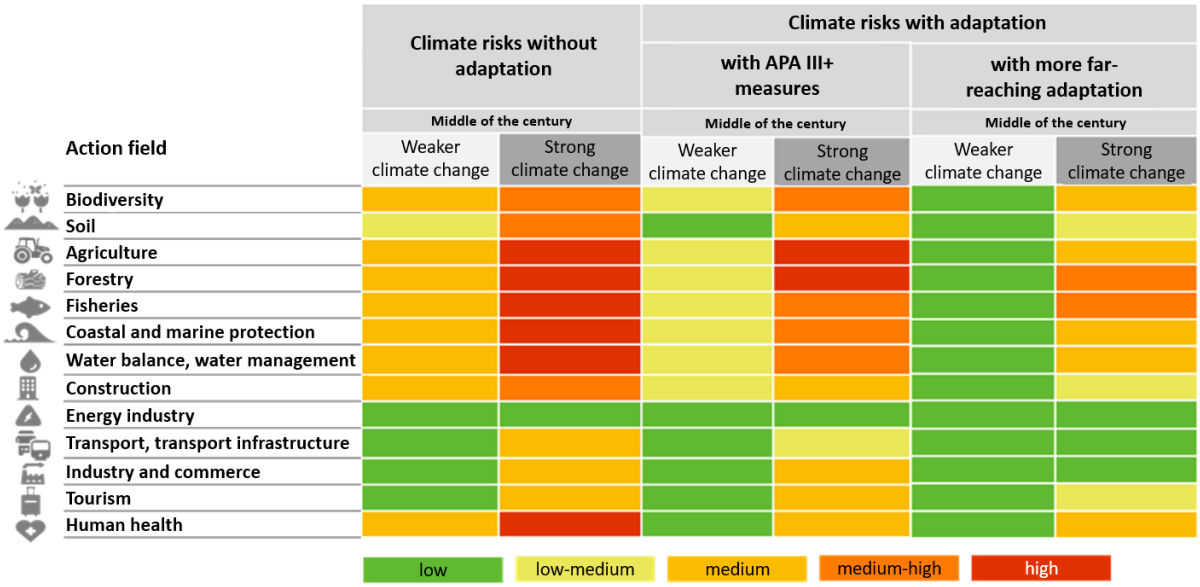
[41] German Environment Agency (2021): Climate Impact and Risk Assessment 2021 for Germany. https://www.umweltbundesamt.de/publikationen/KWRA-English-Summary

[42] However, the period from 2014 to 2023 was already 2.3°C warmer in Germany than when measurements began (see section2.1).

In future, people's health may be put at risk by more intense heat stress, for example, and an increase in allergic reactions to airborne allergens and other climate-related effects. Furthermore, current research is looking at the extent to which climate change in Germany is contributing to an increase in ultraviolet (UV) radiation exposure in humans and thus the risk of UV-related diseases, such as eye and skin cancer. Even if the development of UV exposure and the associated occurrence of disease cannot yet be accurately predicted, the current incidence of disease is reason enough for effective measures to prevent UV-related diseases. Buildings and infrastructure, such as transport routes, are also affected by the impacts of climate change and can be damaged, for example, by fluvial flooding or heavy rainfall events. More frequent low-water events and longer periods of low water levels can affect the navigability of waterways.

There are many adaptation options in Germany. Many climate risks can be significantly mitigated by adaptation measures, especially in the case of weaker climate change. In particular, economic systems that use nature should make sustainable and climate-resilient use of nature's resources. In the event of strong climate change, further adaptation measures will be increasingly needed, some of which will be more far-reaching. For some climate risks – for example, the impacts of climate change on mountain ecosystems – adaptation is already reaching its absolute limits today or will in the near future. These risks can only be prevented by rigorous climate action.

Figure 2: Climate risks with and without adaptation in the case of weaker and strong climate change for 13 action fields of the German Strategy for Adaptation to Climate Change (mid-century)



Note: experts used a five-point scale (low, low-medium, medium, medium-high, high) to evaluate the climate risks in the network of authorities on climate change and adaptation based on current scientific knowledge. Source: adelphi's own table.

Adaptation measures can only take effect in the short term (in less than ten years) for about a third of the more than 100 climate impacts analysed. Many adaptation measures need several decades to take effect. This is particularly true for climate impacts with high climate risks. Only by taking immediate action can many high climate risks be effectively mitigated.

Thirty-one climate impacts requiring very urgent action were identified based on a combination of the level of climate risk and the time needed for the relevant system to adapt (see Table 1). These impacts are of the highest priority for future adaptation targets and measures and can be categorised into the following four key challenges:

- Climate risks from high temperatures and the change in natural systems and resources, particularly for human health
- Climate risks from dry periods (often associated with high temperatures), particularly systems that use or depend on water such as ecosystems, water and land use, resulting from low water levels in rivers and lakes or from water shortage in the soil and lower groundwater levels due to droughts
- Climate risks from heavy rainfall, high water levels, flash flooding and fluvial floods, particularly for systems that are dependent on local conditions, such as soil, infrastructure and buildings, and therefore also for human well-being
- Climate risks due to gradual temperature and sea level rise, particularly for natural systems and systems that use nature, for species composition and food chains, water quality and coastal protection

Table 1: Climate impacts requiring very urgent action

Action field	Climate impact
Soil	Soil erosion by water
	Lack of water in the soil
	Wind erosion
	Production function
Biodiversity	Spread of invasive species
	Damage to water-bound habitats and wetlands
	Damage to forests
Agriculture	Abiotic stress (plants)
	Loss of yields
Forestry	Heat and drought stress
	Pest/disease stress
	Forest fire risk
	Utility: Timber yield
Water balance, water management	Water temperature and ice cover and biological water quality
	Overloading or failure of flood protection systems
	Flash floods (failure of drainage facilities and flood protection systems)
	Groundwater level and groundwater quality
Coastal and marine protection	Water quality and groundwater salinization
	Natural spatial changes on coasts
	Damage or destruction of settlements and infrastructure on the coast
	Overloading of drainage facilities in areas at risk of flooding
Fisheries	Distribution of fish species in rivers
Transport	Navigability of inland waterways (low water)
Construction	Damage to buildings due to river flooding
	Vegetation in settlements
	Urban climate/heat islands
	Indoor climate
Industry and commerce	Impairment of the movement of goods via waterways (inland)
Human health	Heat stress
	Allergic reactions due to aeroallergens of plant origin
	UV-related damage to health (especially skin cancer)

Source: adelphi's own table.

3 Targets, measures and indicators by cluster

The Federal Government's measurable climate adaptation targets, measures and indicators are summarised below for each cluster. They cover priority areas of climate adaptation that can be addressed at federal level due to Germany's federal structure and mainly focus on the climate impacts for Germany identified in the KWRA 2021 that require urgent or very urgent action. Priorities have been set for this first version of the strategy: the 2024 German Strategy for Adaptation to Climate Change does not aim to fully cover all climate risks with measurable targets, as not all climate impacts can be addressed by the Federal Government, nor can all action areas be measured with indicators.

The strategy's target-based approach is completely new; it is designed to be further developed in regular updates every four years (see section 4). The key risks are first described for each cluster followed by an outlook that focuses on future developments, potential additional targets and research needs. To reflect the fact that climate adaptation cannot be fully achieved by the Federal Government on its own, but is instead a collective undertaking of all stakeholders, the outlook also contains recommendations for further measures that fall within the remit of the federal states or other actors. At the same time, the targets at federal level can serve as a framework for adaptation strategies at the federal state or municipal level. Finally, individual overarching issues relevant to climate adaptation that are included in the climate adaptation strategy but are not currently addressed by measurable targets are listed as "action fields" in section 3.8.

The targets are based on the principle that each ministry is independently responsible for specific areas. As such, the targets were developed under the direction of the federal ministries responsible for the specific cluster, in consultation with other relevant ministries and with the support of the respective subordinate authorities. They will also be measured and, if necessary, further developed using this approach. The ministries responsible for the clusters are listed in each section. The strategy and relevant measures are subject to a budgetary proviso (see section 1.1).

The targets have some structural differences due to the broad scope of climate adaptation as a cross-sectoral issue and the large number of stakeholders involved. All targets can be measured in principle, but some targets are not quantified with a reference value and target value, but only indicate a trend. Many targets are broken down into several sub-targets to ensure that they can be measured, at least to some extent. The aim is to achieve most of the targets by 2030, although the timeline for some impact-oriented, long-term targets extends to 2050. Some measure-specific targets are set to be reached as early as 2025/2026. For some targets, the basic data and indicators for measuring progress towards them have not yet been fully developed or formalised.

The most important inter-cluster links are listed at the beginning of each section. This means that the targets of individual action areas and clusters should not be seen as separate from the other clusters, but as part of the overall strategy. For example, issues related to the water balance and water management (**water** cluster) are closely related to landscape hydrology (**land and land use** cluster), water-smart urban development (**urban development, spatial planning and civil protection** cluster) and waterway transportation (**infrastructure** cluster).

Detailed background documents for each cluster can be found in Annex 1 (cluster documents, in German) and form the basis for the summary in this section. Annex 2 (in German) contains the fourth Adaptation Action Plan (APA IV). In addition to the measures to achieve the targets, the Adaptation Action Plan also includes further climate adaptation measures from the federal ministries.

Table 2: Overview of the targets

Cluster	Targets	Code
Infrastructure	Optimise transport and logistics conditions on federal waterways in the event of low water levels by the period 2030 to 2040	I-1
	Reduce the number of incidents and disruptions to road and rail transport caused by weather-related factors such as flooding, heavy rainfall, storms, drought, heat or gravitational mass movements	I-2
	Adapt buildings and properties to protect users, with a particular focus on vulnerable groups	I-3
	Protect buildings and properties, with a particular focus on existing buildings	I-4
	Reduce financial risks associated with buildings	I-5
Land and land use	Minimise the direct and indirect impacts of climate change on biodiversity by 2030	L-1
	Strengthen the resilience of soil to the impacts of climate change	L-2
	Strengthen the resilience of agroecosystems to the impacts of climate	L-3
	Further adapt farms to climate change and build resilience to climate variability and adverse weather conditions	L-4
	Strengthen the adaptability of forests to climate change and their resilience to climate variability and adverse weather conditions (especially extreme weather events and conditions) so that they have favourable conditions for maintaining their functionalities due to their high biodiversity	L-5
Human health and care provision	Strengthen the public's ability to adapt to heat by 2030	G-1
	Strengthen the public's ability to adapt to ultraviolet exposure by 2030	G-2
	Strengthen the public's ability to deal with pollen allergies by 2030	G-3
	Strengthen the public's ability to prevent and deal with infectious diseases facilitated by climate change, especially vector-borne diseases, by 2030	G-4
Urban development, spatial planning and civil protection	Activate urban green spaces to reduce heat stress	S-1
	Achieve a more near-natural water balance for water-smart urban development	S-2
	Develop and introduce climate adaptation monitoring (ex-post) for spatial development plans at the federal state and regional level at the Federal Institute for Research on Building, Urban Affairs and Spatial Development by 2026	S-3
	Improve how future climate change impacts are taken into account when drawing up and updating spatial plans at the federal state and regional level by 2028	S-4
	Expand the reach of warnings to the general public	S-5
	Increase the level of public information and preparedness on the risks associated with climate change, in particular extreme weather events	S-6
	Raise the visibility and attractiveness of volunteering in civil protection	S-7

Water	Preserve available water resources for the long term – water balance and water management	Wa-1
	Strengthen the resilience of the water infrastructure	Wa-2
	Ecology - promote climate-resilient water bodies	Wa-3
Economy	Analysing physical climate risks is an integral part of corporate risk management	Wi-1
	Analysing physical climate risks is an integral part of investment decisions	Wi-2
	Extreme weather events no longer lead to significant losses due to the impacts on company staff and assets in Germany	Wi-3
	German companies can operate successfully on national and international markets with technologies and services in the context of climate adaptation and continuously increase their aggregated added value in line with the trend	Wi-4
Cross-sectoral action areas	By 2030, climate adaptation plans will be available for 80 percent of the municipalities and districts required to do so by the federal states under the Federal Climate Adaptation Act	Ü-1
	Federal expenditure on climate adaptation is surveyed every two years starting in 2026; the Federal Government also collects data on the financial losses due to damage caused by extreme weather events	Ü-2
	Implement climate adaptation research findings faster	Ü-3
	The Federal Government has a national framework with indicators and measures in line with international policy documents and action plans and in accordance with the requirements of the World Heritage Convention so that UNESCO World Heritage sites in Germany can develop climate change mitigation measures and/or climate adaptation strategies or plans (for example as part of their management plans, disaster risk management plans and framework strategies) by 2030	Ü-4
	Adapt federal properties to climate change	Ü-5

Box 1: Vision for a climate-resilient Germany 2060[43]

Germany is a safe, climate-resilient country with a high quality of life, even amid climate change. People live in cities, towns and villages in green, vibrant residential communities that are still good places to live despite changing climate conditions. Climate-adapted cultural, leisure and recreational activities and destinations are accessible to and can be used free of charge by everyone. Accessibility is guaranteed even in very hot weather, for example, by short, shady paths, green corridors between parks, forests on the outskirts of cities and drinking fountains. This has been achieved through measures such as climate-adapted construction, planting greenery and taking climate adaptation into account in all urban development measures and water-smart urban development.

People stay healthy as the climate changes because the necessary conditions are in place. The healthcare system and cities, towns and municipalities have adapted to the impacts of climate change, and the number of deaths and cases of illness caused by climate change has decreased, in part because heat action plans are in place throughout Germany and information services for vulnerable groups are widely used. Cross-institutional and cross-level risk management can respond appropriately to new health, environmental, meteorological, hydrological and maritime hazards and minimise damage due to extreme situations.

Environmentally friendly land use and biodiversity conservation are guaranteed to protect and preserve the natural foundations of our lives despite climate change. Soils, as a limited and valuable resource, continue to fulfil their natural functions that are important for our lives and society. Their key role in flood protection and the landscape hydrology is acknowledged. In a diverse agricultural sector with farms of all sizes, crops adapted to the climate are grown wherever possible using environmentally friendly practices that protect the soil and use water efficiently. Forests are preserved and adapted to the climate, and environmentally friendly land use and biodiversity conservation are ensured. In a diverse forestry sector with forest enterprises of all sizes, environmentally friendly practices that protect the soil and conserve water resources are used, including the conversion to resilient tree species and forest structures.

The supply of water, energy and raw materials, the cornerstones of our society, is ensured even as the impacts of climate change intensify. Society is aware that water is essential to life on Earth and a finite resource that matters to all of us. Sustainable, adapted and climate-resilient water-related infrastructure is available and the quality of surface waters and groundwater remains intact, preventing overuse of water resources. A large number of decentralised water reservoirs collect rainwater so that it can be used during dry periods. Rivers, small watercourses and peatlands have been restored to their natural state wherever possible and practical. Nationwide action plans are in place to ensure that water is distributed and used equitably during dry periods.

The transport infrastructure works reliably. Supply chains are not interrupted even under extreme conditions. Local public transport systems and trains are attractive, reliable and air-conditioned using renewable energy sources. Cycle paths are safe and pleasant even in hot weather and during extreme weather events, for example, thanks to the shade and protection from rain provided by trees and tree-lined roads and streets.

Businesses and workplaces have adapted to the new climate conditions to stay competitive and contribute to preserving prosperity and good working conditions. The population's productivity and health is maintained by ensuring that work, education and business activities are protected from extreme weather conditions. New jobs and career opportunities have emerged as a result of innovation in the climate adaptation sector.

This makes it possible to take precautionary measures to counter the impacts of climate change in Germany, prevent the overuse of resources, preserve nature and the environment in the long term, enable good working and living conditions, maintain economic performance, guarantee social cohesion and, at the same time, take account of intergenerational justice and fulfil our global responsibility.

[43] Note: this vision was created particularly on the basis of the summarised results of the participatory process "Dialogue Climate Adaptation, Managing Life in Climate Change Together". https://www.umweltbundesamt.de/publikationen/empfehlungen- von-buergerinnen-buergern-fuer-die.

Box 2: Contributions of the federal states

Achieving long-term climate adaptation and safeguarding the quality of life in Germany, also for future generations, will require a **concerted effort** on the part of all stakeholders at federal, federal state and municipal level, as well as from the private sector and industry. The federal states, in particular, have an important role to play here, as they are responsible for many issues related to climate adaptation and for implementing specific measures in the federal system. The Federal Government and federal states therefore work closely together on climate adaptation and are in continuous dialogue (see section 1).

Many climate adaptation areas and targets that are not (or cannot be) addressed in this national strategy due to Germany's division of powers in the federal system are therefore covered in the federal states' own climate adaptation strategies, programmes of measures and other relevant strategies. At the same time, the work done by the **federal states** on climate adaptation will also make an important contribution **to achieving the cluster targets in this strategy in a variety of ways**. This is clearly evidenced by the instruments and measures outlined below that were identified by the federal states **in the consultation on the draft of the 2024 German Strategy for Adaptation to Climate Change.**[44]

Measures implemented by the federal states to strengthen the climate resilience of the **transport infrastructure and buildings** range from information services such as a geohazard map in Bavaria to structural requirements such as green roofs for new buildings in Bremen. Bremen considers the adaptation of existing buildings to climate change to be part of building modernisation and is developing measures that aim to harness the potential in integrated urban development plans. Berlin has implemented an integrated urban development plan and a green roof funding programme called GründachPLUS. Rhineland-Palatinate also provides information on climate risks for infrastructure with maps such as for flash flooding and heavy rainfall.

In the area of **land and land use**, for example, climate adaptation in Bavaria is supported by extensive renaturation measures, funding for voluntary greening measures and peatland restoration as part of land consolidation to improve the quality of the ecological environment. Bavaria is also committed to climate-resilient forests with its forest conversion initiative Waldumbauoffensive 2030 in private and municipal forests, forest conversion in state forests and the Bergwaldoffensive, Bavaria's mountain forest initiative. Measures taken by the federal states also help make the targets in the **land and land use** cluster more measurable. Lower Saxony, for example, collects important data on agricultural and forestry soils as part of its long-term soil monitoring, which also includes monitoring such non-substance-related changes as soil loss due to wind and water erosion and compaction. Schleswig-Holstein is seeking to reduce land take to less than 1.3 ha/day in accordance with its State Development Plan and its soil protection programme.

In the area of **human health**, for example, Bremen, Saarland, Rhineland-Palatinate and Hesse contribute to protecting people's health in hot weather with heat action plans for their respective federal states. In Saarland, a central coordination office organises and supports heat protection measures between municipalities, institutions and associations. Based on an expert opinion on the heat action plan, Brandenburg has set up a heat protection network that coordinates and promotes heat protection measures throughout the federal state. Baden-Württemberg and Hesse have implemented their own tiger mosquito monitoring programmes. Many federal states are raising awareness and informing the public through campaigns and events about the climate change-related increase in health risks posed by heat, vector-borne diseases such as tick-borne encephalitis, dengue and Zika infections transmitted by the tiger mosquito, and UV exposure.

In the **urban development** sub-cluster, many federal states have their own measures in place to improve urban green spaces and the near-natural water balance. For example, one of the strategic goals of Berliner Wasserbetriebe, the Berlin water management authority, is to turn Berlin into a "sponge city" and pursue water-smart urban development. To achieve this goal, the Berlin Water Act (Berliner Wassergesetz) prioritises allowing rainwater to infiltrate the ground over other alternatives for its removal. Baden-Württemberg is developing a strategy for urban water resource management and promotes municipal approaches to urban water resource management.

[44] The list of selected examples is not meant to be exhaustive. Important: there are also a number of other programmes and measures in the federal states.

Bremen uses a guideline-based climate adaptation check to take climate adaptation issues into account in all formal and informal urban planning and decision-making processes in the context of urban land-use planning, strategies and tenders. North Rhine-Westphalia also promotes water-smart urban development, for example through municipal de-sealing and greening programmes. It provides information and advice to municipalities with the digital climate atlas of North Rhine-Westphalia with heavy rainfall maps and green roof registers, and a municipal advisory service for climate impact adaptation in North Rhine-Westphalia.

In the area of **civil protection**, the federal states contribute to expanding the reach of warnings and the degree of civil preparedness. Thuringia, for example, supports the municipal siren network and is working with the central control centres to improve the warning infrastructure. Schleswig-Holstein informs the general public of the dangers of flooding, storm surges, heavy rainfall and about precautionary measures through its campaign Wasserstark.SH. Saxony provides information on flood and other risks using early warning systems for small catchment areas and large-scale maps indicating the risk of heavy rainfall. With its “Bereit wie nie” (more prepared than ever) campaign, North Rhine-Westphalia is helping the public to protect themselves and promoting volunteering for disaster response.

In the area of **water**, for example, the federal states’ water-related strategies, such as Saxony’s Future Water action programme, contribute to climate adaptation. The programme addresses the need for action in areas such as water retention, adaptation of dam infrastructure and heavy rainfall risk management. Baden-Württemberg has a water supply master plan that makes recommendations for precautionary water management based on the predicted development of water resources up to 2050. Brandenburg has its own funding programmes to address the areas of landscape hydrology, flood protection and water body restoration. Climate surcharges can help strengthen the resilience of the water infrastructure. In Bavaria, for example, a surcharge of 15 percent of the design discharge rate applies to new flood protection systems and those being modernised. The KLIWA federal states (Baden-Württemberg, Bavaria, Hesse, Rhineland-Palatinate and Saarland) are also working on a harmonised method to determine and implement appropriate climate surcharges for surface waters.

The goal of a climate-resilient **economy** is also being addressed at regional level with various measures. For example, North Rhine-Westphalia supports a number of pilot projects (klimasicher and Klima.Profit NRW) that provide advice on how companies can adapt to climate change, and promotes networking and advisory services for private sector stakeholders through the Klimaanpassung&Unternehmen.NRW network. In addition, initial analyses and experiences are available on how to define the climate adaptation sector in North Rhine-Westphalia. In Saxony, too, the Saxony Environmental and Climate Alliance is a network that brings together businesses and the state administration.

3.1 Infrastructure cluster

Ministries responsible for the cluster	Federal Ministry for Digital and Transport, Federal Ministry for Housing, Urban Development and Building
Inter-cluster links	**Land and land use** cluster **Human health and care provision** cluster **Urban development, spatial planning and civil protection** cluster **Water** cluster **Economy** cluster **Cross-sectoral action areas** cluster
Complete cluster paper	see Annex 1 (in German)

3.1.1 Significant risks: why we have to act

In the **transport and transport infrastructure** action area, the need for action arises directly from meteorological (for example, heat, storms), hydrological (for example, high water levels, low water levels, flash flooding) and maritime extremes (for example, storm surges, extreme waves). Rising sea levels and their impact on seaports and shipping, for example, will also become more significant in future. Given recent events, priorities include the navigability of inland waterways when water levels are low and the prevention of damage and disruption to road and rail transport due to the effects of the weather.

In recent years, extended periods of low water have frequently and significantly restricted shipping on inland waterways. These transport limitations had a noticeable impact on the economy and the population. They are usually caused by prolonged summer dry periods and heat waves, sometimes combined with low levels of stored water (for example, snow, groundwater, dams) in the river basins of inland waterways.

The focus for road and rail transport is on damage and impediments caused by heavy rainfall events, floods, storms, droughts and gravitational mass movements (such as landslides or rockfalls), as well as damage to traffic control systems, overhead lines and power supply systems. These adversely affect road and rail infrastructure and can lead to accidents and disruptions to both transport systems. Damage to transport infrastructure leads to increasing maintenance costs for the responsible authorities. Interruptions and impairments of the transport systems can affect traffic safety and business processes and disrupt people's daily routines.

In the **buildings** action area, risks arise from intense urbanisation in connection with climate changes that have occurred or are expected to occur in future. In this context, further intensification of natural hazards and their effects on buildings (storms, hail, heavy rainfall, flooding, heat, drought, dry periods, heat islands, etc.) can further exacerbate climate risk if the structural and planning frameworks are not adapted. The studies conducted to date show that these factors have different impacts at regional and sometimes even local level. However, there is a general trend towards an increase in extreme weather events with significant potential for damage. If the structural design is inadequate, these impacts can damage structures and buildings and/or endanger the goods and equipment they contain, as well as the people using them. If the need for individual adaptation of the structural design is not addressed, the quality of time people spend in buildings and properties or open spaces can be significantly diminished. The risk of damage to buildings, land and property, or danger to users, may increase.

No measurable climate adaptation target has yet been defined for the **energy** action area. Since the KWRA 2021 expects a relatively low propensity for risk in this action area in the medium term, it will

only be looked at in more detail in future updates of the strategy. When it comes to energy, the focus is currently on bringing about the energy transition to mitigate climate change.

3.1.2 Targets, indicators and measures/instruments in the transport and transport infrastructure action area

The Federal Government is taking action to tackle the risks in the **transport and transport infrastructure** action area using the following targets:

Table 3: Targets in the transport and transport infrastructure action area

Code	Target
I-1	Optimise transport and logistics conditions on federal waterways in the event of low water levels by the period 2030 to 2040
I-2	Reduce the number of incidents and disruptions to road and rail transport caused by weather-related factors such as flooding, heavy rainfall, storms, drought, heat or gravitational mass movements

In the **transport and transport infrastructure** action area, the overarching goal is to make transport systems more resilient to the impacts of climate change. This will be achieved by reducing susceptibility to disruptions and increasing reliability. The precautionary adaptation strategy and the measures it contains can contribute to the further development of existing transport infrastructure planning procedures and methods, and therefore to ensuring that the resilience of transport infrastructure to climate change is given greater consideration. Factors that could affect progress towards the targets and measures in the **transport and transport infrastructure** action area are listed in the cluster paper in the Annex (in German).

Target 1: Optimise transport and logistics conditions on federal waterways in the event of low water levels by the period 2030 to 2040

The aim is to ensure and, if possible, optimise transport and logistics conditions on federal waterways to guarantee the security of supply to the population and industry during low-water events, which are expected to be more intense, more frequent and last longer as a result of climate change. This will be achieved by measures such as improved information and forecasting, more reliable infrastructure and adapted availability of ship types optimised for low water levels, as well as improved logistics and transport solutions (including intermodal approaches). This will be supported by more resilient and durable waterway infrastructure that can be used under extreme conditions.

Indicators: the existing indicators of the 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change already cover individual aspects of the "water supply – waterways – shipping transport – logistics – supply" impact cascade, but they are insufficient for measuring the success of adaptation to low-water events to capture the integrated effect of the various measures (see below). This means that additional sub-indicators for the above-mentioned waterway-related target may still need to be developed.

It can be assumed that a package of measures, such as those in the Rhine action programme for low water (see below), are more effective in achieving the target than selected individual measures. The aim is therefore to develop an **integrated indicator that measures the success of adaptation in relation to the above-mentioned target across all measures** (I-1.a). The following indicators from the 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change and the KWRA 2021 can be incorporated into this indicator:

    - Low water discharge (indicator WW-I-6 from the Monitoring Report of the German Strategy for Adaptation to Climate Change or KWRA indicator WW-KL-01: low water)
- Low-water restrictions to shipping on the Rhine (indicator VE-I-2 from the Monitoring Report of the German Strategy for Adaptation to Climate Change)
- Navigability of inland waterways (low water) (KWRA indicator VE-KL-01)
- Impaired transport of goods on inland waterways (KWRA indicator IG-KL-09)

In response to a low-water situation in 2018, measures relating to the waterways target were introduced and implemented as early as 2018. For this reason, a baseline before 2018 is used to determine the progress of adaptation as these measures have already contributed to reaching the target. The goal of an adaptation measure is considered achieved when vulnerability in the actual situation is minimised in comparison to the theoretical situation (without adaptation). Owing to the considerable natural variability, it is possible that no extreme low water situations occur over longer periods and that adaptation successes measured in terms of reducing vulnerability (increasing resilience) do not occur, or their effects are hardly quantifiable. It is important that this is not interpreted as a failure to achieve the target.

The following are specific federal measures that will contribute to achieving target 1. Overall, progress has been made in systematically incorporating climate change into planning measures on federal waterways. However, not all measures are equally effective and feasible in all waterway areas. Catchment area and route-specific conditions, but also the respective criticality, for example, with regard to transport interruptions (for example, affecting the security of supply to industry and the population), must be taken into account.

- Implementation of the Rhine action programme for low water (I-1.1): this involves a package of eight measures that aim to ensure reliably calculable transport conditions on the Rhine even if there is an increase in extreme low water events (for example, forecasting services, climate data services, ship technology, elimination of bottlenecks or assessment of hydraulic engineering and water management options). Some of the measures can be applied to other waterways (such as the Danube and Elbe Rivers) and are already being implemented. These measures are described in detail in I-1.2 to I-1.6 below.
- Provision and further development of operational low/medium water forecasts for selected waterways (I-1.2): knowledge of impending water levels at an early stage is important for inland shipping and industry to be able to plan more reliably. Further development is focused on improved risk assessment using probability-based forecast products and longer forecast periods.
- Provision of current depth information for ship navigation on selected waterways (I-1.3): to enable ship's crews to make better use of existing channel depths, steps are being taken to provide up-to-date depth information in the electronic inland navigation chart (Inland ECDIS).
- Adaptation of transport plans/optimisation of transport and loading containers (I-1.4): in addition to making full use of transport options and for creating and making full use of storage and loading capacities, the development and availability of ship types optimised for low water, the adaptation of transport plans (including modified contract design) and the digitalisation of shipping can offer approaches for optimisation in the event of extreme low water and ensuring transport capacities. These measures will be implemented by companies; the Federal Ministry for Digital and Transport supports the relevant considerations and discussions. The conversion of the existing fleet to optimise for low water is supported by the Federal Ministry for Digital and Transport funding programme for the sustainable modernisation of inland waterway ships.
- Continue to eliminate bottlenecks on selected waterways (especially the Rhine) and pursue

innovative solutions in hydraulic engineering and water management (I-1.5): the relevant measures included in the requirements plan for federal waterways will help to increase resilience to the impacts of climate change and the more severe low water periods that will occur as a result. Of particular relevance are localised bottlenecks that can be alleviated by river engineering measures (for example, measures to support water levels), taking into account the ecological requirements of the waterway and the adjacent habitats. In addition to implementing conventional measures, it is important to pursue innovative, integrative approaches to water engineering and water management, as well as coordinated cross-regional strategies.

- Contributions to water resource management adapted to low water/droughts (I-1.6): to prepare for times of low runoff, it is necessary to review and, if necessary, adapt water resource management (see also National Water Strategy). As in other action areas, measures that generally mitigate water shortages in seasons of low water levels (summer/autumn) also have an impact on waterways. To this end, close cooperation and coordination with the federal states will take place.
- Continuation of the Federal Waterways and Shipping Administration Climate Adaptation process (I-1.7): steps are already being taken to systematically integrate the impacts of climate change into the planning processes under the remit of the Federal Waterways and Shipping Administration.

Target 2: Reduce the number of incidents and disruptions to road and rail transport caused by weather-related factors such as flooding, heavy rainfall, storms, drought, heat or gravitational mass movements

The aim is to measurably increase the resilience of the federal trunk road and rail infrastructure to the threat of damage from heavy rainfall, flooding, heat, drought, storms and gravitational mass movements by 2050, and to reduce weather-related accidents.

To achieve this goal, it is essential to start by creating a comprehensive set of basic data. This will include information on damage and disruptions caused by natural hazards, as well as on measures taken to remedy damage and disruptions. This basic data will be used to develop a better understanding of the factors involved and to establish the necessary warning structures (response management). This systemic approach will be supplemented by specific measures that directly contribute to reducing the vulnerability of the respective infrastructure.

The indicators for the land-based target have **not yet been defined** and are currently still being formulated.

Federal measures that will contribute to achieving target 2 can be divided into two categories:

1. Measures to improve the available data to gain a better understanding or in relation to warning structures

- Creation of a centralised systematic reporting system and establishment of a central database, taking into account existing, possibly decentralised reporting systems and databases, to record damage and disruptions caused by natural hazards categorised in terms of time and location (I-2.1): including the measures carried out to remedy damage and disruptions and to ensure traffic safety
- Partially automated monitoring of critical rail infrastructure components (I-2.2): throughout the federal rail network within the scope of what is technically feasible by 2030
- Monitoring of vegetation close to railway tracks (50m) (I-2.3): for the entire federal rail network by 2030 through regular (partially) automated monitoring in particularly at-risk

sections

- Regular monitoring of ground movements close to railway tracks (200m from the track) (I-2.4): in potentially at-risk parts of the entire federal railway network (for example former mining areas, low mountain ranges)
- Identification of risks from heavy rainfall, drought and heat, storms and flooding and regular monitoring of all rail network sections and infrastructure classified as vulnerable (I-2.5): for the entire federal rail network and all buildings relevant to operations, such as passenger stations, signal boxes and depots, by 2030
- Development of nationwide simulations on the impacts of climate change-related risks on transport routes (for example, flooding as a result of heavy rainfall events) (I-2.6)

2. Measures to increase the resilience of the transport infrastructure in regulations and their local implementation

- Increase in the resilience of rail transport infrastructure (railways and operationally necessary buildings, including transport stations) against physical climate risks by adapting the structural and technical facilities (I-2.7)
- Development of a flood resilience audit as part of road planning (I-2.8)
- Improvement in resilience to heavy rainfall events and flooding of low-lying sections of road and railway tracks and, in particular, tunnels for both modes of transport (I-2.9)
- Strengthening of the resilience of road embankments against landslides and washouts due to heavy rainfall events by investigating cause-and-effect mechanisms for the development of structural adaptation options (I-2.10)
- Structural safety measures at an early stage of all sections of federal railway lines that are additionally at risk from landslides and rockfalls due to climate change (I-2.11): throughout the federal rail network
- Review and, if necessary, modification of the regulations for both modes of transport (I-2.12)
- Introduction of adaptation measures to ensure the health of people travelling on the rail infrastructure, particularly at train stations and stops, with a focus on heat and UV exposure (I-2.13)

Federal measures that will contribute to achieving both target 1 and target 2:

- Review of the further development of the procedures and methods of the Federal Government's transport infrastructure planning (for the three modes of transport: rail, road and waterway), including by taking appropriate account of the benefits of measures that increase resilience as part of the new Federal Transport Infrastructure and Mobility Plan 2040 (I-0.1)
- Intensification of the Federal Ministry for Digital and Transport's research programmes on climate impacts (I-0.2): specific climate impact analyses relating to individual action areas, regions, transport networks and buildings are an important basis for decision-making. The methodological tools must be kept current and further developed. This is the responsibility of the Federal Ministry for Digital and Transport, particularly the intermodal expert network.
- DAS Climate and Water Data Service (I-0.3): the operational DAS Climate and Water Data Service was launched as a quality-assured information and data source on climate change and its impacts. The service provides key data and advisory services for the Federal Government's climate impact analyses, for example, including the meteorological, hydrological and oceanographic impacts of climate change. It would therefore also be

useful to expand the data to include other climate impacts that are particularly important for terrestrial transport, such as gravitational mass movements and storm damage to trees.

3.1.3 Targets, indicators and measures/instruments in the buildings action area

The Federal Government is tackling the risks in the **buildings** action area using the following targets:

Table 4: Targets in the buildings action area

Code	Target
I-3	Adapt buildings and properties to protect users, with a particular focus on vulnerable groups
I-4	Protect buildings and properties, with a particular focus on existing buildings
I-5	Reduce financial risks associated with buildings

The focus of the **buildings** action area is on residential and non-residential buildings[45] and their properties and outdoor spaces for people to use and spend time in, without addressing specific ownership or operating structures. Measures to counteract the effects of summer heat and dry periods, heavy rainfall, flooding and fluvial floods are considered particularly urgent in the short term. Both extremes have so far had the most severe negative impacts on users (including circulatory problems and higher mortality[46]) and buildings (extent of damage, loss of value). Other forms of natural hazards, such as storms and hail, are addressed through specific measures.

In the **buildings** action area, the most important targets are to prevent damage to building structures, reduce financial risks and, in particular, protect users without subjecting vulnerable groups to excessive economic and social strains. The above-mentioned targets will be achieved through measures with multiple benefits and functions, where possible in conjunction with (ecosystem) services that have an impact on the neighbourhood and urban development (synergy effects). Any mention of structural adaptation measures in the following should always be understood to include nature-based solutions such as green roofs and façades and greenery planted around properties. These often achieve physical effects comparable to purely structural or technical solutions, but they also have other positive effects, such as increasing water retention capacity to take pressure off municipal sewer systems, improving the microclimate, increasing biodiversity and other similar effects.

The planning sovereignty of municipalities and the legal responsibilities of the federal states remain unaffected.

The key stakeholders involved in achieving these targets are owners, operators, users and other stakeholders in the construction industry.[47] Since the Federal Government has no direct regulatory authority over existing buildings and their owners or operators, the methods listed for achieving the targets are essentially informative, educational and motivational, and can only be effective in collaboration with other stakeholders. In some areas, methods with a steering function (legal instruments, for example through the Federal Building Code (BauGB), and standardising instruments) and methods with a stimulating function (financial incentives) will also be used. Factors that could affect progress towards the targets and measures in the **buildings** action area are listed in the cluster paper in Annex 1 (in German).

If additional requirements are needed to increase the resilience of buildings to the impacts of climate change, these must be carefully weighed against other construction policy goals as well as other goals, for example, that aim to limit construction costs and provide affordable housing in a short time

[45] For information on building typologies, functions and uses, see Annex 1 cluster papers (in German).

[46] https://www.umweltbundesamt.de/daten/umwelt-gesundheit/gesundheitsrisiken-durch-hitze#gesundheitsrisiko-hitze.

[47] see Annex 1 cluster papers (in German).

frame, and must not conflict with them.

Target 3: Adapt buildings and properties to protect users, with a particular focus on vulnerable groups

The realities of climate change require that both new and existing buildings be planned and constructed with adaptation in mind. The aim is to provide users with safe buildings that do not compromise on living standards.

Indicators to measure progress towards targets:

- **Indicator to show increased resilience in the building sector** (I-3.a): despite the increasing risk of severe weather, it must be possible to demonstrate that buildings and properties can generally provide better protection for users and particularly vulnerable groups
- **Implementation of the proposed measures** that contribute to the adaptation of buildings and properties to protect users (I-3.b) (qualitative)

Federal measures and associated instruments that will contribute to achieving target 3:

- Compilation and evaluation of basic data, including evaluation of past damage (I-3.1): to improve the assessment of the condition of existing buildings and particularly endangered and vulnerable building typologies and construction methods, coupled with information on particularly vulnerable groups and their regional distribution in Germany. This will be achieved by developing directly measurable quantitative indicators and basic data, taking into account existing data.
- Improvement of the planning basis and assessment instruments for climate impact adaptation in buildings (I-3.2): in particular, the specific requirements of social and public institutions and buildings for vulnerable groups. This will be achieved by reviewing and improving standards, developing and introducing guidelines and planning tools and harmonising evaluation methods.
- Improving the framework for the structural adaptation of buildings to make them climate-resilient (I-3.3): in particular for social and public institutions and providers of affordable housing/housing for vulnerable groups. This can be achieved by reviewing and, if necessary, adapting and updating the funding criteria in federal funding programmes, as well as creating new funding opportunities to support nature-based solutions and structural adaptation measures on buildings and properties. When public funds are used, the structural quality of the precautionary measures must be ensured in future.
- Better information and knowledge transfer in the area of precautionary structural measures for heavy rainfall, heat and indoor climate, as well as support through low-threshold access to information material (I-3.4): with a particular focus on vulnerable groups and the respective at-risk and susceptible buildings. This can be achieved through public relations work and general knowledge transfer (see also **water** cluster, sub-target 2.II).

Target 4: Protect buildings and properties, with a particular focus on existing buildings

Urban land-use planning and building law already have a range of possibilities for promoting climate adaptation when planning new buildings. In comparison, the options for altering existing buildings are extremely limited, in particular due to grandfathering rights under building law.

Technical regulations and standards form a sound basis for taking natural hazards and extreme weather events into account in buildings, but so far they have not provided any structural calculations to use as a basis when factoring in future impacts of climate change. There is currently no binding requirement to take climate impacts into account at building level.

Indicators: a key measure of progress is the **downward trend in insurance claims expenditure for buildings**. However, what is important here is that the long-term sustained trend towards reducing the damage caused by severe weather events occurs **despite the upward trend in the risk of severe weather**. The following indicator was taken from the 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change: claims expenditure for property insurance (I-4.a).

The development of the following indicator is being assessed to measure the cost of damage: damage to buildings due to extreme weather events (I-0.a).

Further indicators under review relate to the development, provision, introduction, implementation and further development of the measures and instruments for achieving the target:

- Number of buildings with a climate impact and risk analysis (climate risk check) (I-4.b)
- Number of building permits in designated floodplains and risk areas (I-4.c)
- Funding amounts disbursed for building- and property-related climate adaptation measures (I-4.d)
- Implementation of defined measures to protect buildings and properties, with a special focus on existing buildings (I-4.e) (qualitative)

Federal measures/instruments that will contribute to achieving target 4:

- Documentation of improvements to the condition of existing buildings (I-4.1): this will be achieved by developing and introducing nationwide documentation of existing buildings (for example, in the form of a building register) that includes an assessment of climate change mitigation and adaptation as part of an interoperable data ecosystem for buildings
- Precautionary construction measures and retrofitting of existing buildings for more effective damage prevention (I-4.2): this will be achieved by providing pooled information, for example on climate-adapted construction and renovation, on precautionary structural measures for the public and private sectors to protect against flooding and heat in buildings and against further extreme weather events (such as storms or hail) and on risk perception as a basis for assessing the necessary adaptation measures. Findings from previous accidents and damage profiles must be evaluated and the knowledge gained, for example on better and sustainable reconstruction, must be made available in the form of practical aids and by presenting positive examples of implementation.
- Development and provision of a methodology including basic data to create climate impact and risk analyses for new and existing buildings and properties (climate risk check) (I-4.3): this will be achieved by providing information, data and maps (federal/federal state/other stakeholders), providing a digital tool to simplify and customise the assessment of building- and property-related risks, for example by further developing the existing geographical information system (GIS-ImmoRisk Naturgefahren), provided that the necessary resources are made available, are based on an assessment system for sustainable building (for example, BNB 2.0) and take into account existing requirements.
- Review and, if necessary, adaptation and continuation of existing federal funding programmes (I-4.4): when public funds are used, the quality of the precautionary structural measures must be ensured.
- Strengthening of climate adaptation and removal of obstacles in technical regulations for properties, buildings and their technical equipment (I-4.5): for example, encouragement to take account of future climate forecast data in the basic design, for example in flood protection certification or in summer heat protection, as well as establishment of blue-green infrastructure for buildings and properties and the assessment of ways to take the effects of building physics into account. Adverse effects on climate change mitigation must be

prevented. Review of whether to introduce a maximum indoor temperature benchmark for buildings used by vulnerable groups (users) to support target I-3. This will be achieved by a review and, if necessary, input from the Federal Government to make adjustments.

- Removal of legal barriers to climate adaptation (I-4.6): including with regard to the interdependency between buildings, properties and neighbourhoods. This will be achieved by a review and, if necessary, further adaptation of existing legislation, such as in the area of building planning law, for example, assessing the possibility of a green space factor to measure the extent of building use.
- Improvement of precautionary measures to counter dry periods and drought (I-4.7): by maintaining the natural water balance, for example, by strengthening blue-green infrastructure in public and private buildings and water-smart property development, also to maintain the natural soil balance, or by structural measures. One way to achieve this could be to develop a water footprint on a scientific basis or a similar tool for the life cycle assessment of buildings.
- Promotion of innovation and development of climate-adapted construction on a scientific basis (I-4.8): there is inadequate research, for example, on the possible system performance of buildings with different structural and design solutions and, for example, the effect of materials on the building shell and construction. There is also a need for research in the development of uniform qualitative and quantitative requirements and targets for climate-adapted construction and renovation, as well as with regard to possibly incorporating these into building planning law, building law, building planning and exterior design, for sustainable construction solutions, as well as within the framework of certification schemes and funding law. This will be achieved by ministerial research and research funding, in particular the Federal Ministry for Housing, Urban Development and Building's ZukunftBau innovative construction programme (see also the **urban and settlement development** action area).
- Promotion of the dissemination of information on the services provided by ecosystems and nature-based solutions for climate adaptation in the area of buildings and properties, as well as the possible integration of these, at least in new buildings (I-4.9): for example, strengthening the multifunctionality and multiple uses of components and land areas to mitigate the risk of damage due to heavy rainfall and heat. This can be achieved by providing information to the Federal Government, federal states and municipalities, consultants, planners and property developers and managers on the impact of measures and the costs and benefits of individual buildings and structural adaptation measures as part of a profitability analysis.

Target 5: Reduce financial risks associated with buildings

Taking account of the impacts of climate change in the design of both new and existing buildings is essential to keeping financial risks manageable in the long term, not only for owners and operators but also for the general public. The main focus for reducing the financial risks is on developing a climate impact and risk analysis (climate risk check) tailored to the property that is made available to building owners and operators and provides recommendations for structural adaptation.

Indicators here:

- **Public expenditure** to cover uninsured losses in euros (I-5.a)
- **Damage to buildings** due to extreme weather events (I-0.a, see target I-4)
- **Implementation of defined measures** to reduce financial risks through structural prevention (I-5.b) (qualitative)

Federal measures that will contribute to achieving target 5:[48]:

- Evaluation of basic data for better assessment of the condition of existing buildings and continued adaptation to the impacts of climate change, as well as for better assessment of the extent of damage and its structural and spatial distribution (I-5.1): if necessary, in coordination with, for example, the German Insurance Association. This will be achieved in part by combining, developing and updating directly measurable quantitative indicators.
- Development of a climate impact and risk analysis for buildings and properties (climate risk check) (I-5.2): this can be achieved by providing information, data and maps (by the Federal Government/federal states/municipalities) and a methodology (Federal Government/federal states/other stakeholders) to provide an instrument for simplified and tailored assessment of building- and property-related risks.[49]
- Development of practical and application-oriented economic feasibility analyses for the evaluation of individual buildings and structural adaptation measures (I-5.3): to facilitate adaptation and investment decisions for buildings and properties. This can be achieved, for example, by providing low-threshold cost-benefit analyses of risks and a practical methodology for weighing up other sustainability goals.

3.1.4 Outlook

In the **transport and transport infrastructure** action area, integrating indicators that evaluate the overall success of adaptation in terms of social or economic impacts are currently still at an experimental stage and require further development and testing. To develop these indicators, more precise data and system analyses of the loading and manufacturing industries are required. Further research is needed in the development and provision of resilience indicators for the transport infrastructure. In this context, the development of a standardised methodology for assessing resilience levels, which may be based, among other things, on the research findings of the Federal Ministry for Digital and Transport's expert network, would be conceivable.

It is essential to develop a systematic reporting system on the effects of natural hazards and the measures taken to remedy damage and disruptions and to ensure the safety of transport by rail, road and waterway. The federal states and stakeholders involved will be included in systematic reporting with the aim of getting the best possible overview.

Furthermore, it is important to set up a data collection process together with other stakeholders for waterways. Water is relevant as a resource for many action areas and stakeholders, independently of its relevance for transport on inland waterways. Particularly when water levels are low, there may be a wide range of competing claims for water use. Data on water use, the effects of adaptation (for example, retention, blue-green infrastructure) and the dynamics of the water balance that is required across catchment areas and clusters must be compiled and made available for shared use. Similarly, when measures are implemented, transport infrastructure and infrastructure-related areas also have ecological and other functions (for example, rivers used as waterways) and that here, too, there must be cross-sectoral collaboration. This includes continuing and intensifying the existing dialogue with the federal states.

Existing data needs in the area of **transport** must also be satisfied; for example, data on the usability of intermodal transport options (availability of individual modes of transport, capacity of transhipment sites), must be systematically collected.

[48] Measures to protect buildings and property (target 3) can also help to reduce financial risks, for example, measure I-4.2 Precautionary construction measures and retrofitting of existing buildings for more effective damage prevention.
[49] see measure I-4.3 Development and provision of a methodology including basic data to create climate impact and risk analyses for new and existing buildings and properties (climate risk check).

Another element for a coherent approach, particularly in the area of infrastructure, is the integration of climate change into standards and guidelines, as well as into the methodology of the Federal Transport Infrastructure Plan.

In the **buildings** action area, there is a need for research into a standardised climate impact and risk analysis for buildings and properties (climate risk check), initiated by the Federal Government. This research is intended to support building stakeholders (mainly owners, operators and consultants) in conducting standardised and straightforward assessments of the resilience of buildings and properties. The emphasis here is on (streamlined) application-oriented and practical measurement, evaluation and documentation. Furthermore, research and development is needed to analyse the effectiveness of various measures and to identify and develop suitable indicators for monitoring. Practical research into suitable construction and design solutions will also be pursued. In addition, requirements and verification methods must be developed that enable greater incorporation of climate adaptation into funding programmes and assessment systems. Existing approaches to the life cycle assessment of buildings need to be based on scientific evidence and further developed with regard to water- and biodiversity-related aspects. They also need to be linked to proven planning and assessment methods in line with current building policy and sustainability considerations. To take an integrated approach to meeting research needs, it would be useful to evaluate the cost efficiency of adaptation measures to ensure resilience where it is needed and to the appropriate extent.

To provide reliable data as a basis for analysing effectiveness, it would be helpful to develop and implement nationwide documentation and a regular evaluation of the resilience of existing buildings by federal and federal state authorities. This documentation will consolidate and analyse the various data that is already available on properties and buildings (see also building register). This will help to reduce the need for additional documentation for property developers, owners and other stakeholders.

There is a need for research into climate change in the context of inequality, which manifests itself in social and spatial inequality.

All the stakeholders mentioned in this action area are encouraged to take account of the existing and intensifying risks arising from the impacts of climate change in their activities:

Owners and operators need to assess their existing buildings for deficiencies, implement structural, organisational and operational measures, and ensure that any other risks are financially covered (see section 3.8 **Personal preparedness** action field) and use the information provided by the Federal Government, federal states, municipalities and other organisations for adaptation.

Federal states and municipalities need to identify regional and local hazards resulting from climate change and publish and disseminate the findings for the various target groups. The federal states and municipalities need to make better use of the existing levers under building planning and building law, for example, by introducing specifications in urban land-use planning and by adapting the Model Building Regulation (Musterbauordnung) and federal state building regulations, for example by introducing design statutes for open spaces that take climate change into account.

To alleviate the shortage of skilled workers, colleges, universities and further education centres of industry associations and chambers of commerce need to focus more on teaching and training about precautionary structural measures and building adaptation. Consultants and professionals in the construction industry (architects, engineers, tradespeople; in particular the relevant industry associations/chambers of commerce) also need to share knowledge about structural measures to counter the impacts of climate change through training and further education programmes, and, where appropriate, introduce low-threshold advisory services and provide training for experts in the event of damage.

3.2 Land and land use cluster

Ministries responsible for the cluster	Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection; Federal Ministry of Food and Agriculture
Inter-cluster links	**Infrastructure** cluster **Urban development, spatial planning and civil protection** cluster **Water** cluster **Cross-sectoral action areas** cluster
Complete cluster paper	see Annex 1 (in German)

3.2.1 Significant risks: why we have to act

For the **biodiversity** action area, there is, according to the KWRA 2021, a very urgent need for action for climate impacts (a) damage to forests, (b) damage to water-bound habitats and wetlands, and (c) the spread of invasive species. Urgent action is needed to address the climate impacts (d) ecosystem services, (e) damage to coastal ecosystems, (f) shifts in ranges and declines in populations and (g) loss of genetic diversity. The time needed for biodiversity to adapt may take several decades. This is why it is important to generally promote biodiversity conservation, especially given the reality of climate change, increasing the resilience of humans and nature to the impacts of climate change.

According to the KWRA 2021 and the 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change, the impacts of climate change on the **soil** action area are as follows: (a) loss of soil fertility due to increasing erosion, (b) landslides and mudslides in mountainous regions, (c) water shortage in agriculture and forestry (including the issue of water reuse), (d) decline in the infiltration water rate and thus in groundwater recharge, (e) implications for soil biodiversity and the soil (carbon) balance, (f) impact on the filtering function for nitrates and contaminants (and therefore on the quality of the groundwater) and (g) long-term decrease in soil fertility.

According to the KWRA 2021, there is a very urgent need for action in the **agriculture** action area to address the climate impacts (a) abiotic stress (plants) and (b) yield losses. It has become evident in recent years how important it is for farms to adapt to the above-mentioned climate risks. These years have been challenging for many farms and in many regions of Germany, particularly due to prolonged dry periods and, in some places, heavy rainfall, sometimes resulting in significant fluctuations and losses in yields. The stability of production systems, particularly in agriculture and forestry, requires an intact environment and a range of varieties and breeds that can be used as needed.

For the **woodlands and forestry** action area, the KWRA 2021 defines a very urgent need for action for the climate impacts (a) heat and drought stress, (b) stress from pests/diseases and (c) utility: timber yield. Urgent action is needed for the climate impacts (d) damage from windthrow and (e) utility: recreation. The interaction between abiotic and biotic risks poses a major challenge for forests in Germany and their ecosystem services, as forest growing conditions are changing to an extent that can reduce growth and threaten the forest stand, and has a negative impact on forest yield, quality and stability.

The Federal Government is tackling these risks using the following targets:

Table 5: Targets in the **land and land use** cluster

Code	Target
L-1	Minimise the direct and indirect impacts of climate change on biodiversity by 2030
L-2	Strengthen the resilience of soil to the impacts of climate change
L-3	Strengthen the resilience of agroecosystems to the impacts of climate change
L-4	Further adapt farms to climate change and build resilience to climate variability and adverse weather conditions
L-5	Strengthen the adaptability of forests to climate change and their resilience to climate variability and adverse weather conditions (especially extreme weather events and conditions) so that they have favourable conditions for maintaining their functionalities due to their high biodiversity

Box 3: Targets, indicators and measures/instruments within the framework of other sectoral strategies, action programmes and EU regulations

Implementation of climate adaptation measures and instruments for from the following strategies, programmes and target agreements will make a significant contribution to achieving the targets in the **land and land use** cluster:

- EU Biodiversity Strategy for 2030
- EU Soil Strategy for 2030
- Federal Agriculture Ministry's Arable Farming Strategy
- Federal Action Plan on Nature-based Solutions for Climate and Biodiversity
- Federation-Länder target agreement on climate change mitigation through peat soil conservation
- Federal Agriculture Ministry's Protein Crop Strategy
- Federal Agriculture Ministry's Food and Nutrition Strategy
- National Bioeconomy Strategy
- Federal Agriculture Ministry's national programmes for plant, animal, forestry and aquatic genetic resources
- National Peatland Protection Strategy
- National Humus Programme
- National Action Plan on Sustainable Use of Plant Protection Products
- Federal Organic Farming Scheme/Federal Agriculture Ministry's 2030 Organic Strategy
- Federal Agriculture Ministry's National Strategy on Genetic Resources for Food, Agriculture, Forestry and Fisheries
- National Strategy on Biological Diversity 2030
- Programme of measures from the agenda for adapting agriculture, forestry, fisheries and aquaculture to climate change
- National Water Strategy
- Federal Agriculture Ministry's Peat Use Reduction Strategy
- Forest Strategy 2050
- EU Green Infrastructure Strategy

The following ongoing relevant national and international processes may also give rise to further target specifications or new measures and indicators:

- Framework for Action on Biodiversity for Food and Agriculture
- EU Farm to Fork Strategy
- EU Mission: A Soil Deal for Europe implementation plan
- EU Nature Restoration Law: national implementation
- Germany's National Sustainable Development Strategy: further development of the indicators
- Development of national indicators for the evaluation of biodiversity in agricultural landscapes (MonViA)
- National Adaptation Plan (NAP [UNFCCC]): to be reviewed by the Federal Government at least every five years (implementation of Directive 2009/128/EC)
- Amended Federal Soil Protection Act
- Proposal for an EU regulation for soil monitoring and resilience (Soil Monitoring Law)

3.2.2 Targets, indicators and measures/instruments in the biodiversity action area

Box 4: Strengthen the adaptive capacity and resilience of species and ecosystems by 2030

Biodiversity loss and climate change are closely related and exacerbate one another. Climate change has a significant impact on biodiversity, for example by moving habitats and causing droughts and extreme heat. At the same time, a high level of biodiversity contributes to better adaptation to and prevention of the impacts of climate change. In general, diverse, near-natural ecosystems are more resilient to the changes caused by climate change and can recover more easily and buffer disturbances. Many ecosystems also act as carbon sinks and are thus a natural defence against climate change. If they are unable to function, the climate targets cannot be achieved. These services provided by nature are irretrievably lost when biodiversity is lost. The resilience and adaptive capacity of species and ecosystems must therefore be strengthened by preserving and enhancing biodiversity.

The National Strategy on Biological Diversity (NBS) has been the central nature conservation strategy of the Federal Government since 2007. The continued development of the NBS for the period up to 2030, the NBS 2030, is crucial to the protection of biodiversity in Germany. The NBS 2030 aims to implement the Kunming-Montreal Global Biodiversity Framework (GBF) and contribute to the implementation of the EU Nature Restoration Law and the EU Biodiversity Strategy for 2030. The intention is to incorporate the NBS 2030 targets, indicators and measures that demonstrate synergies with climate adaptation as part of the next update of the adaptation strategy. Sub-targets are planned for the update in the areas of interlinked biotopes and networks, protected areas, nature-based solutions, invasive alien species, structural and landscape elements, organic farming, biodiversity in agricultural landscapes, cities and restoration.

Target 1: Minimise the direct and indirect impacts of climate change on biodiversity by 2030

Changes in temperature and precipitation patterns, as well as in the frequency of extreme events, affect the seasonal development, behaviour, reproduction, competitiveness and food web relationships of species in the long term. In addition, climate change also has indirect effects on biodiversity, for example, as a result of the implementation of climate change mitigation and adaptation measures. To conserve biodiversity in Germany, the direct and indirect impacts of climate change on biodiversity must be minimised.

Sub-target 1.I (landscape planning): By 2030, climate adaptation that is compatible with nature will be implemented as part of new and updated landscape plans

In future, landscape planning needs to take greater account of the dynamics and changes in the landscape caused by climate change with a view to supporting adaptation options and flexible development opportunities. Although the impacts of climate change and the resulting requirements for habitat and species protection are increasingly being incorporated into landscape programmes and landscape framework plans, the vast majority of these plans still lack specific details on targets and measures related to climate change.

The indicator for measuring progress towards target 1.I is **"Inclusion of climate change in landscape programmes and landscape framework plans"** (L-1.1.a) (indicator from the Monitoring Report on the German Strategy for Adaptation to Climate Change). With a view to this sub-target, a separate evaluation is being considered.

One federal measure that will contribute to achieving sub-target 1.I:

- Development of recommendations for better integration of adaptation measures into landscape planning and information on planning and implementation (L-1.1)

For the next update of the climate adaptation strategy, sub-targets are also planned for nature-based solutions and alien species (see Box 4).

3.2.3 Targets, indicators and measures/instruments in the soil action area

Target 2: Strengthen the resilience of soil to the impacts of climate change

The aim is for soils to be resistant to climate variability and adverse weather conditions (in particular extreme weather and temperatures).

Sub-target 2.I (land take): By 2030, the average daily increase in the area used for human settlements and transport (land take) must be reduced to less than 30 hectares per day. The aim is to achieve circular land use management (net-zero land consumption) by 2050.

Land take reduces the options for climate adaptation, particularly with regard to areas designated for protection against flooding and heavy rainfall. Biodiversity and the adaptive capacities of plants and animals are also affected, as landscapes are fragmented and habitats destroyed as a result of land take. In most cases, new settlement and transport areas are created on agricultural land, which is often high-quality soil. These conversions of farmland, forest or grassland have a significant environmental impact and intensify the negative impacts of climate change.

One indicator for measuring progress towards sub-target 2.I is the development of **settlement and transport areas** (L-2.1.a), which is already reflected in the Monitoring Report on the German Strategy for Adaptation to Climate Change. Since the land used for projects to expand the use of renewable energy is also partly covered by the "Settlement and transport areas" indicator, this indicator will be further developed in parallel with the respective indicator in the German Sustainable Development Strategy to ensure that the share of renewable energy in total land use is reflected more transparently in future.

Federal measures that will contribute to achieving sub-target 2.I are based on the new land take target of Germany's National Sustainable Development Strategy.

Sub-target 2.II (soil sealing): Reduce the increase in soil sealing

About half (45 percent) of settlement and transport areas are sealed, which is about 6.54 percent of Germany's total area. Depending on the degree of sealing, the natural soil functions and ecosystem services of the soil are impaired or can no longer be provided, for example, water infiltration, carbon storage and the cooling function of the soil. If the soil is permanently closed off from air and water, the soil fauna is lost. Soil fauna fulfils important functions for the preservation and regeneration of fertile soils. Ultimately, soil sealing is difficult and costly to reverse. Even after de-sealing, the soil condition remains impaired because the natural structure of the soil has been disturbed and impurities often remain in the soil. New soil fauna only develop over longer periods of time, meaning that natural soil fertility is also delayed and often cannot be restored to its previous quality.

One indicator for measuring progress towards sub-target 2.II is the **degree of soil sealing** (L-2.2.a), which represents the **percentage and change of soil sealing as a proportion of the total area nationwide**. In the long term, the aim is to develop an indicator that not only takes into account the area, but also, where appropriate, the qualitative loss (soil function fulfilment). This indicator is related to the "Permeable surfaces" indicator in the **urban and settlement development** action area. Over the course of the methodical development of the indicators, it needs to be determined to what

extent the two indicators share basic data and can complement one another in their further development, with the aim of efficiently capturing the data and minimising the effort needed.

Federal measures that will contribute to achieving sub-target 2.II:

- Alignment of legal requirements and funding policy measures to more effectively leverage the potential for the reuse of surfaces that have already been sealed and the use of land for multiple purposes (multifunctionality) (L-2.1)
- Reduction in the degree of soil sealing, even in the case of land take for settlement and transport areas and as part of land recycling measures with the aim of restoring nature and increasing soil cooling capacity (L-2.2)

In future, it is likely to remain useful to identify the potential for de-sealing soil and, where possible, to establish a link to the restoration of soil functions (for example, water absorption, water storage capacity, soil cooling function (particularly relevant in urban areas in summer), habitats for large numbers of soil organisms (important for soil fertility). The aim is also to step up measures to de-seal the soil as a significant contribution to climate adaptation (for example, in the Action Plan on Nature-based Solutions for Climate and Biodiversity).

Sub-target 2.III (good ecological status): By 2026, a definition and assessment of good ecological soil status will be developed and suitable climate adaptation measures (as well as climate change mitigation measures) will be identified

The services provided by soil organisms are extremely important for climate change mitigation and adaptation, as they play a major role in soil and humus formation and thus make a significant contribution to a stable soil water balance. Assessing and defining good ecological soil status is an important prerequisite for identifying suitable measures for climate change mitigation and adaptation.

Earthworm fauna (L-2.3.a) can be considered the first indicator for measuring progress towards sub-target 2.III. The indicator focuses on the development of the mean abundance and species number of different life form types of earthworm fauna at monitoring stations on agricultural and grassland soils. They are already being analysed in some federal states, but it will be necessary to expand and standardise the existing soil monitoring programmes.

For a comprehensive assessment of soil biodiversity, it will also be necessary to consider other key functional groups in the soil food web, such as enchytraeids, soil mites, collembolans, nematodes, protists, bacteria and fungi. In this context, further indicators are being developed as part of the nationwide monitoring of biodiversity in agricultural landscapes.

One federal measure that will contribute to achieving sub-target 2.III is measure 6.4. Strengthening soil biodiversity (L-2.3) from the Action Plan on Nature-based Solutions for Climate and Biodiversity.

Common targets, indicators and measures/instruments in the soil and agriculture action

The following sub-targets are listed, which contribute equally to ***strengthening the resilience of soil to the impacts of climate change*** (target L-2) and to ***strengthening the resilience of agroecosystems to the impacts of climate change*** (target L-3).

Sub-target 0.I (carbon storage function and soil humus): Depending on the baseline situation, the humus content in mineral soils used for agriculture must be maintained or increased by locally adapted measures. For locations with very low humus levels due to farming methods, humus levels must be increased by adapting farming practices.

Humus in agricultural soils is essential for key functions such as soil life, soil fertility, water balance, nutrient availability and erosion reduction. Due to the considerable spatial heterogeneity of humus content resulting from a combination of natural conditions (source rock, climate), use and land-use history, there are major differences in the potential for increasing humus content through farming practices. For this reason, the target must distinguish between soils with high and low humus content.

One existing indicator for measuring progress towards sub-target 0.I is the **humus content of agricultural and grassland soils** (L-0.1.a), which is already reflected in the Monitoring Report on the German Strategy for Adaptation to Climate Change.[50]

Another indicator must be developed based on ongoing processes at EU level (Nature Restoration Law, Soil Monitoring Law). It would also be conceivable to monitor measures to increase humus content, but this would require the development of another indicator.

Federal measures that will contribute to achieving sub-target 0.I:

- Support for measures that increase humus content and protect soil biodiversity that go beyond good agricultural practice[51] (L 0.1): this is also possible through agricultural funding (EU Common Agricultural Policy (CAP) by means of conditionality and eco-regulations, the Joint Task for the Improvement of Agricultural Structures and Coastal Protection [GAK]), for example, diverse crop rotations with (preferably deep root) legumes and/or catch crops, promoting grazing, conservation tillage, ground cover, agroforestry systems
- Establishment of a monitoring system for implementation of measures to increase humus content using data from the EU's Integrated Administration and Control System (IACS) (L-0.2)
- Systematic promotion of the preservation and creation of structural elements and areas, especially in agricultural landscapes, with a positive impact on climate and biodiversity (hedges, hedgerows, agroforestry systems, tree rows and copses) (measure 6.1 from the Action Plan on Nature-based Solutions for Climate and Biodiversity) (L-0.3)
- Further expansion of organic farming to achieve the target of 30 percent organic farming on agricultural land by 2030 (measure 6.2 from the Action Plan on Nature-based Solutions for Climate and Biodiversity) (L-0.4)
- Establishment of a National Soil Monitoring Centre (measure 8.3 from the Action Plan on Nature-based Solutions for Climate and Biodiversity) (L-0.5)
- Research and knowledge transfer to practical application of different farming measures that increase humus content under different local conditions (L-0.6)

Sub-target 0.II (peat soils): In the medium to long term, the decomposition of organic matter in peat soils and other organic soils (hereinafter referred to as peat soils) will be stopped by long-term and extensive rewetting and raising the water level with farming practices that preserve the peat. Adequate water management at catchment level will ensure their preservation. By 2030, annual greenhouse gas emissions from organic soils will be reduced by 5 million tonnes of CO2 equivalents (Federation-Länder target agreement on climate change mitigation through peat soil conservation and the National Peatland Protection Strategy). Peat used for private gardening will be phased out by 2026. Peat use in commercial horticulture will be largely phased out by 2030 (Federal Agriculture Ministry's Peat Use Reduction Strategy).

[50] The humus reserves in forest soils are represented in the **woodlands and forestry** action area in sub-target 6.III.
[51] Guidelines for best practices are described and defined in the relevant legislation and in the law on funding and state aid. Further information on best practices is available at: Gute fachliche Praxis – Bodenbewirtschaftung und Bodenschutz (ble-medienservice.de).

Policies and measures to protect peat soils are already enshrined in the Federation-*Länder* target agreement on climate change mitigation through peat soil conservation and in the National Peatland Protection Strategy, including for agricultural and forestry use of peat soils and for the inclusion of peat soils in decentralised flood management. In relation to the targets in the **water** cluster, peat soils must be included in water management planning (see **water** cluster).

Indicators: the methods for surveying and regionalising indicators developed as part of the peatland monitoring programme for climate protection (Moorbodenmonitoring für den Klimaschutz, MoMoK) can be used to measure progress towards achieving sub-target 0.II. The following indicators can be used to describe the conditions of peat soils:

- Peatland water levels (L-0.2.a)
- (Typical peatland) biotope types or habitat types according to Annex I of the Habitats Directive from corresponding mapping (L-0.2.b)
- Changes in terrain elevation (L-0.2.c)
- Change in carbon stocks in soil (L-0.2.d)
- Existence of paludiculture and measures to raise the water level of agricultural land (for example low-impact peatland damming) (IACS) (L-0.2.e).

Data for indicators L-0.2.a to L-0.2.d will be collected at sampling sites under the peatland monitoring programme for climate protection. Vegetation data is available for relatively large areas, at least for protected biotopes/Habitat Directive habitat types. However, the peatland monitoring programme for climate protection must be continued if the intention is to use the indicators to measure progress towards the targets. Better methods to regionalise peatland water levels are currently being developed.

Federal measures that will contribute to achieving sub-target 0.II:

- Support for locally adapted wet use of peatlands (measure 1.4 from the Action Plan on Nature-based Solutions for Climate and Biodiversity) (L-0.7)
- Continuation of the peatland monitoring programme for climate protection (L-0.8)
- Development of a database that documents the measures taken to raise water levels and pinpoints them to the exact area (L-0.9)
- The use of peat substitutes in publicly funded landscaping and gardening contracts is addressed as part of the Peat Use Reduction Strategy (L-0.10)
- Measures to provide information on the use of peat substitutes in gardening and research projects on peat substitutes (L-0.11)

In addition, measures to raise awareness among owners, land managers, the public and policymakers, as set out in the National Peatland Protection Strategy, can help to achieve the targets.

One federal measure that will contribute to achieving sub-targets 0.I and 0.II is funding for investments in machines and equipment for strengthening natural soil functions in agricultural landscapes, in particular for (peat) soil conservation tillage (measure 6.5 from the Action Plan on Nature-based Solutions for Climate and Biodiversity) (L-12).

Sub-target 0.III (crop diversity): The aim is to increase the percentage of farms with a range of at least five different crop plants and a balanced share of leafy vegetables and cereals, winter and summer crops, field vegetables, catch crops and undersown crops, and to grow legumes (pulses for grain and legumes (mixtures) for green harvesting) on 10 percent of arable land in Germany (2035 Arable Farming Strategy, Protein Crop Strategy)

Diversified crop rotations promote humus formation and biodiversity in the agricultural landscape. Expanding the range of crops grown increases the resilience of agriculture to the

impacts of climate change. It also helps to prevent plant protection problems (pest infestation, weed pressure, resistance) and reduces the risk of yield losses due to abiotic stress. In addition to agronomic and environmental advantages, diversified crop rotation can also contribute to operational risk management given climate change, provided that the crops grown are in demand and economically viable.

Possible indicators, which can be derived in part from the agricultural statistics and are listed in the 2035 Arable Farming Strategy, are the **land farmed for crops including catch crops** (L-0.3.a) and the **scope of farmed legumes and legume quantities** (L-0.3.b). However, a monitoring system would first have to be developed to track the development of the range of crops grown on individual farms (L-0.3.c). An initial starting point for this would be to take advantage of funding opportunities for "diverse crops" under the CAP and the Joint Task for the Improvement of Agricultural Structures and Coastal Protection. The indicator for habitat diversity developed as part of the monitoring of biodiversity in agricultural landscapes project (L-0.3.d) would also be suitable for measuring progress towards sub-target 0.III.

Federal measures that will contribute to achieving sub-target 0.III:

- Promotion of diverse crops as part of agricultural funding (L-0.13)
- Promotion of sales opportunities for crops (for example, emmer wheat or parsnips) that help to promote crop diversification (L-0.14): as part of the implementation of the Genetic Resources Strategy
- Creation of sales opportunities for legumes (L-0.15): as part of the implementation of the Protein Plant Strategy
- Research on climate-resilient crop rotations, mixed cropping, crop types and varieties (L-0.16)
- Knowledge transfer: implementation in agricultural advisory services and training (L-0.17).

Sub-target 0.IV (permanent grassland): The current proportion of agricultural land accounted for by permanent grassland will at least be maintained. Possible competition for land use with other adaptation targets (rewetting of peat soils, planting of forests on erosion-prone sites) and other policy goals such as the promotion of sustainable, animal-friendly grazing of ruminants are included in the target evaluation.

Permanent grassland has a higher capacity for water infiltration and water retention than agricultural land, as well as being less susceptible to erosion due to the year-round soil cover provided by permanent vegetation. This is particularly important for climate adaptation in locations prone to erosion due to the increasing intensity and frequency of heavy rainfall.

One possible indicator for measuring progress towards sub-target 0.IV is the **proportion of permanent grassland used for agricultural purposes** (L-0.4.a), which is already included in the Monitoring Report on the German Strategy for Adaptation to Climate Change.

In the context of increasing need for land, for example for rewetting peatlands, the contribution of permanent grassland to climate adaptation and the associated target must be continuously evaluated.

One federal measure that will contribute to achieving sub-target 0.IV:

- Preservation and expansion of permanent grassland, especially permanent grassland with high nature conservation value, promotion of livestock grazing (L-0.18)

Sub-target 0.V (erosion): By 2030, reduce soil erosion by means of locally adapted farming practices, land use and land consolidation on at least 50 percent of the areas exceeding the

threshold of significance for soil erosion by water (modelled) and on at least 50 percent of agricultural land potentially affected by moderate to high levels of wind erosion

With the predicted increase in the erosive force of precipitation, more intense individual events will likely lead to more frequent damage to soil, agricultural crops and infrastructure if no adaptation measures are taken. Indicators: modelling of erosion rates is suitable for measuring progress towards sub-target 0.V. Modelling can initially be carried out for **soil erosion caused by water** (L-0.5.a). The effect of farming practices can be reflected in the modelling using the farming data from the existing IACS administrative data. For soil erosion caused by wind, a corresponding procedure would have to be developed. As long as no modelling is available, the **measures taken to combat wind erosion** (L-0.5.b) could be evaluated by observing areas with potential for medium or high wind erosion.

Federal measures that will contribute to achieving sub-target 0.V:

- Support for measures to prevent erosion (Common Agricultural Policy, Joint Task for the Improvement of Agricultural Structures and Coastal Protection, Action Plan on Nature-based Solutions for Climate and Biodiversity) that go beyond best practice[52] (L 0.19): year-round soil cover, agroforestry systems, conservation tillage, creation of structural elements, soil tillage across slopes, shortening of slope lengths, greening of depth lines prone to erosion, growing of crops with deep roots, structural diversity in agricultural landscapes
- Promotion of knowledge transfer for better agricultural advisory services (L-0.20)

One federal measure that will contribute to achieving sub-targets 0.I, 0.III, 0.IV and 0.V:

- Use of IACS data for monitoring/indicators (see L-0.2)

Sub-target 0.VI (harmful soil compaction): Harmful soil compaction is effectively prevented

Soil compaction can result in crop losses, increased surface runoff and erosion (harmful soil compaction). This exacerbates climate risks such as dry soil, reliable crop yields, erosion and more severe runoff peaks, as well as the impairment of soil biodiversity and the nutrient balance.

There is currently no standardised method for determining actual soil compaction in Germany. Mandatory threshold values, above which soil compaction is considered harmful, are currently being developed.

Indicators: data describing the **changes over time in the number of soil trafficability days** (L-0.6.a) as an indicator of the development of the compaction risk is available and needs to be turned into an indicator. Other indicators should also be developed.

Federal measures that will contribute to achieving sub-target 0.VI:

- Knowledge transfer to farmers about soil compaction and how to prevent it (L-0.21): in particular, the nationwide provision of up-to-date information about soil trafficability, as supplied by the German Meteorological Service on the ISABEL portal[53]
- Support for the purchase and use of technology that protects soil when driving on agricultural land (L-0.22)
- Thresholds for identifying soil damage due to compaction (L-0.23): expected to be available in 2025

For the next update of the climate adaptation strategy, a sub-target is also planned for “structure and landscape elements” (see Box 4).

[52] Guidelines for best practices are described and defined in the relevant legislation and in the law on funding and state aid. Further information on best practices is available at: Gute fachliche Praxis – Bodenbewirtschaftung und Bodenschutz (ble- medienservice.de).
[53] Information system for agricultural meteorological advisory services for the federal states (ISABEL).

3.2.4 Targets, indicators and measures/instruments in the agriculture action area

Ziel 3: : Strengthen the resilience of agroecosystems to the impacts of climate change. The aim is sustainable, locally adapted farming practices and structures that contribute to a diverse range of biotopes and structures, biodiversity in agricultural landscapes, a climate-resilient land use system and a stable supply of agricultural raw materials.

The goals of sustainable and locally adapted farming practices include risk diversification through the preservation and promotion of biodiversity, the promotion of nature's ability to self-regulate, the increase in the water absorption and retention capacity of soils and the efficient use of resources and nutrients.

Sub-target 3.I (pesticides): Reduce the use and risk of pesticides by 50 percent overall by 2030 (see reference period 2011 to 2013) (EU Farm to Fork Strategy)

The main function of agriculture is to provide the population with safe, high-quality and affordable food. At the same time, agricultural practices must be designed to protect public health and the environment, and to preserve biodiversity. As a result, the aim is to rigorously implement integrated pest management and to ambitiously reduce the use of chemical pesticides in line with the Farm to Fork Strategy. Many of the adaptation measures needed to reduce dependency on pesticides (integrated pest management, selection of crop varieties, crop rotation, etc.) will strengthen the resilience of agroecosystems to climate change in the long term, thus also securing the potential yield in changing climate conditions.

Possible indicators for measuring progress towards sub-target 3.I are the intensity of pesticide use (treatment index) (L-3.1.a) and an estimate of the risks associated with use (risk indicator SYNOPS[54]) (L-3.1.b).

It must be regularly reviewed to what extent these indicators need to be added to or further developed if they are to reflect the targeted reduction in the quantities of pesticides actually used and the risk.

Federal measures that will contribute to achieving sub-target 3.I:

- Improve integrated pest management (L-3.1)
- Further development and expansion of the guidelines for integrated plant protection with the aim of supporting the establishment of resilient cropping systems and strengthening measures to promote ecosystem services in cropping systems (L-3.2)
- Support environmentally friendly and resource-efficient technology for the precise application of pesticides (L-3.3)
- Continue research funding on potential for reduction, climate change and biotic potential for damage, impact assessment, knowledge transfer and development of advisory strategies and tools (L-3.4)
- Support for knowledge transfer: implementation in agricultural advisory services and training (L-3.5)
- Interlinking of the reduction programmes of the federal states with the activities of the Federal Government (L-3.6)
- Further development of measures as part of the Joint Task for the Improvement of Agricultural Structures and Coastal Protection related to avoiding the use of chemically synthesised pesticides

[54] Model for Synoptic Evaluation of the Risk Potential of Chemical Plant Protection Products (SYNOPS).

(L-3.7): for example, expansion to include preventative and non-chemical methods of preventing infestation with harmful organisms (that are becoming more prevalent due to climate change).

Sub-target 3.II (genetic diversity of crop varieties/livestock breeds): The regionally adapted, endangered crop varieties and livestock breeds are protected by in situ/on-farm and ex situ conservation

The genetic diversity of the crop varieties and livestock breeds on farms is an essential basis for future uses and innovations in agriculture. Preserving diversity therefore contributes to ensuring the supply of food and raw materials in the face of climate change. Diverse agricultural systems are also potentially better equipped to withstand the impacts of climate change, such as an increase in pests and pathogens.

Possible indicators for measuring (and, if necessary, further specifying) progress towards sub-target 3.II are the indicators that were used to assess SDG 2.5. This will involve measuring the number of (a) plant and (b) animal genetic resources for food and agriculture that are securely stored in the medium or long term (L-3.2.a; L-3.2.b) and the proportion of native breeds classified as threatened with extinction (L-3.2.c).

Further indicators are currently being developed as part of a project to monitor biodiversity in agricultural landscapes (MonViA). Federal measures that will contribute to achieving sub-target 3.II:

- Support for standardised surveying, collection, evaluation, classification and documentation of genetic diversity for food and agriculture for its preservation and sustainable use (L-3.8)
- Strengthening of breeding research to provide resistant, productive, robust and climate-adapted plant varieties, livestock breeds and forest reproductive material for sustainable production systems (L-3.9)
- Securing of long-term financing of facilities and networks for the preservation of genetic resources (ex situ, in situ and on-farm) (L-3.10)
- Support for the preservation and sustainable use of genetic resources for food and agriculture in the context of agricultural funding (L-3.11)

For the next update of the strategy, sub-targets are also planned for organic farming and biodiversity in agricultural landscapes (see Box 4).

Target 4: Further adapt farms to climate change and build resilience to climate variability and adverse weather conditions. The goal is farms that sustainably produce sufficient high-quality food and animal feed as well as bio-based raw materials, even under challenging climate conditions.

Climate change affects the yield, quality and stability of prevailing cropping systems. Ensuring the production of food, animal feed and biogenic raw materials in the necessary quality and quantity is therefore a primary goal of the adaptation efforts in agriculture. Adequate availability of land and the prevention of soil sealing are prerequisites for implementing these projects. For this reason, achieving the target of limiting land take for settlement and transport areas to less than 30 hectares per day by 2030 is an important factor.

Sub-target 4.I (yield fluctuations): There is no increase in yield fluctuations and no decline in the economic resilience of farms due to climate change until 2030 (and then continuously until 2050)

The past few years have been climatically challenging for many farms and regions in Germany, and have been accompanied in some cases by significant fluctuations and losses in yield, particularly due to severe drought and extreme precipitation events. In addition to the risks posed by changing conditions and extreme weather events, changes in what is grown or farm management to adapt to climate change can also result in additional costs. The reference value for the formulation of the quantitative target has yet to be defined.

The indicator for measuring **yield fluctuations** (L-4.1.a) from the Monitoring Report on the German Strategy for Adaptation to Climate Change must be further developed, among other things, in relation to regionality, the inclusion of other crops and differentiating between other influences on yields. In addition to methodological development, statistical surveys also need to be further developed.

An indicator to measure the economic resilience of farms as a whole (L-4.1.b) that shows the impacts of climate change and how the implementation of adaptation measures affects the economic resilience of the sector has yet to be developed. Possible starting points include the number of insolvencies or Cash Flow III. Based on this indicator, the target could be further defined in terms of the target value and the year the target is to be achieved.

Federal measures that will contribute to achieving sub-target 4.I:

- (Further) development of indicators on yield fluctuations and for measuring the economic resilience of farms (L-4.1)
- Greater integration of adaptation solutions at landscape level and of systemic approaches (L-4.2)
- Implementation of regional, integrated water management plans that define sustainable and cross-sectoral use of water in rural areas, including for agriculture (see **water** cluster, measure Wa-1.13)

Sub-target 4.II (security of supply): There is no climate change-related decline in the security of supply of agricultural products until 2030 (and then continuously until 2050)

The impacts of large-scale extreme weather conditions, in particular long-lasting droughts, can reduce the security of supply of food, animal feed and agricultural raw materials. Climate adaptation measures must therefore address the security of supply of key agricultural goods, also in the event of extreme weather conditions in Germany and abroad.

Defining specific quantitative targets is currently only possible or useful to a limited extent because the necessary scientific basis and suitable indicators are lacking. No quantitative adaptation targets have been formulated in the relevant strategies to date.

Indicators: one starting point for monitoring the security of supply is the degree of **self-sufficiency for key agricultural goods** (L-4.2.a). This is already determined annually by the Federal Agency for Agriculture and Food (Bundesanstalt für Landwirtschaft und Ernährung, BLE) for some agricultural goods. There is currently no indicator that also takes into account the import/export relationships of the agricultural sector for supply and food security in the context of climate change. However, one will be developed later on in the process.

Federal measures that will contribute to achieving sub-target 4.II:

- Establishment of an indicator system for monitoring the security of supply (L-4.3)
- Development of a national strategy for vulnerability analysis (stress tests) for value chains/supply chains/food chains (L-4.4)

Sub-target 4.III (adaptation practices): The adaptation practices of farms are subject to continuous monitoring. The share of agricultural land with obligations to improve climate adaptation that are linked to support from the CAP will be 21.09 percent by 2027 continuously adjusted in line with CAP result indicators).

The decision to implement adaptation measures lies with the farms. In order to remove barriers to implementation, the Federal Government, in addition to agricultural funding for individual measures, must do more to improve the information available to farms on the impacts of climate change and adaptation options and how they affect farm profitability. It must also provide the infrastructure needed to deliver this information. In addition, the requirements need to be less bureaucratic and verification simplified.

The indicators for the adaptation practices of farms in the Monitoring Report on the German Strategy for Adaptation to Climate Change are only suitable in part for measuring the quantitative progress towards achieving the targets, as they focus on individual adaptation options. One potential indicator to measure progress towards sub-target 4.III is the **share of agricultural land with obligations to improve climate adaptation that are linked to support from the CAP** (L-4.3.a). In future, the range of interventions that are eligible for funding and that can be counted towards the proportion of the agricultural area with commitments must focus even more closely on climate adaptation. The available interventions will therefore be continuously evaluated and, if necessary, adapted or new interventions developed.

Federal measures that will contribute to achieving sub-target 4.III:

- Further development of the indicators for the adaptation practices of farms (L-4.5)
- Research and demonstration projects/transfer of knowledge into practice for suitable operational climate adaptation measures (L-4.6): such as climate-adapted varieties and crops, agricultural water management, adapted nutrient management, etc.

Federal measures that will contribute to achieving sub-targets 4.I and 4.III:

- Promotion of climate adaptation measures that make a contribution to climate adaptation beyond the farm, through the Common Agricultural Policy and Joint Task for the Improvement of Agricultural Structures and Coastal Protection (L-4.7): for example, by strengthening water retention in the landscape, through erosion control or efficient water management
- Stronger links between agricultural funding and the implementation of relevant national strategies (L-4.8): for example the National Water Strategy or the National Peatland Protection Strategy.

3.2.5 Targets, indicators und measures/instrument in the woodlands and forestry action area

Target 5: Climate-resilient forests and adaptive near-natural forest management: strengthen the adaptability of forests to climate change and their resilience to climate variability and adverse weather conditions (especially extreme weather and weather conditions) so that they have favourable conditions for maintaining their functionalities due to their high biodiversity.

Sub-target 5.I (forest conversion and climate-adapted forest management): By 2030, the extent of forest conversion (conversion area and reforestation area, with changes in or enrichment of tree species – predominantly native tree species and suitable origins) and the extent of forest area supported by the Climate-adapted Forest Management funding programme (funding area) averages 100,000 hectares per year (including reforestation area, with changes in tree species)

More diversity also leads to more climate resilience in forests. Due to the devastating effects of the drought years 2018 to 2020, considerable additional funds were provided, primarily by the federal and federal state governments, to accelerate the conversion of forests into species-rich and climate-resilient forests and enable the reforestation of disaster areas. When selecting and combining tree species, the predicted progression of climate change over the entire lifespan of the forest stand must be taken into account.

The **extent of forest conversion** (L-5.1.a) and the additional forest area that has been converted to climate-adapted forest management (L-5.1.b) are suitable indicators for measuring progress towards sub-target 5.I. The existing indicator from the Monitoring Report on the German Strategy for Adaptation to Climate Change must be further developed, taking into account and strengthening natural processes (conversion area in private forests and municipalities with and without funding, inclusion of reforestation areas, forest area with funding from the Climate-adapted Forest Management funding programme). In addition, suitable indicators from the National Forest Inventory can be used (including the naturalness of the tree species composition, structural diversity and natural regeneration).

Federal measures that will contribute to achieving sub-target 5.I include the further development of funding for forest conversion with conditions for increasing structural and tree species diversity and the use of (in future) predominantly native tree species and origins (L-5.1), as well as the promotion of climate-adapted forest management by private and municipal forest owners and the associated recognition of additional climate change mitigation and biodiversity services (L-5.2).

Sub-target 5.II (forest genetic resources): By 2030, forest genetic resources will be preserved through 50,000 hectares of in situ and 3,000 hectares of ex situ areas

The protected tree stands ensure that genetic diversity can be safeguarded for both common and rare tree species. This creates the basic conditions for maintaining the adaptability of forests. The protected areas of tree stands and seed stocks are used to provide suitable propagation material for reforestation and forest conversion. Research into the properties of tree species is essential to understanding whether these tree species are suitable for planting under the changed climate conditions.

The **conservation of forest genetic resources** indicator (L-5.2.a) already used in the Monitoring Report on the German Strategy for Adaptation to Climate Change is suitable for measuring progress towards sub-target 6.II.

One federal measure that will contribute to achieving sub-targets 5.I and 5.II is research into and development of options and limits of forest climate adaptation with different protection and management measures (L-5.3): a network of experimental plots for testing different management measures (selection of tree species, forest management) in comparison to natural forest development (forest (living) laboratories and a network of practical growing trials).

Sub-target 5.III (forestry information): By 2030, forestry information on adaptation will continuously increase

Informing the people responsible for forest management is essential for implementing overarching adaptation requirements and planning. For this reason, information is needed on the current state of forest research on climate change, on the importance of biodiversity and naturalness for forest climate adaptation, on the effects of extreme weather events and conditions and on suitable forest management measures. At the same time, new ways of providing information through direct training, social media and public relations will be stepped up.

The **silvicultural information on the theme of adaptation** indicator **(100 articles a-1 in the German forestry magazine Allgemeine Forstzeitschrift für Waldwirtschaft und Umweltvorsorge [AFZ] on**

climate change) (L-5.3.a) already used in the Monitoring Report on the German Strategy for Adaptation to Climate Change is suitable for measuring progress towards sub-target 5.III. In addition, the use of federal and federal state funds for training and information on forest adaptation will be considered for use as an indicator.

One measure that will contribute to achieving sub-target 5.III is research into and development of options and limits of forest climate adaptation with different protection and management measures (L-5.3, see above).

Sub-target 5.IV (monitoring): The success of adaptation is continuously monitored using the indicators from the Monitoring Report on the German Strategy for Adaptation to Climate Change, and measures are introduced if developments move in the wrong direction

The Monitoring Report on the German Strategy for Adaptation to Climate Change includes several indicators that, taken together, can provide an overview of the success of the adaptation. Progress is reflected by a **downward trend** in the indicator.

The following indicators already used in the Monitoring Report are suitable for measuring progress towards sub-target 5.IV: **forest condition (crown defoliation)** (L-5.4.a), **dieback rate** (L-5.4.b), **damaged timber – extent of random use** (L-5.4.c), **volume of damaged timber due to the spruce bark beetle** (L-5.4.d), **forest fire hazards and forest fires (burned area)** (L-5.4.e) and **endangered spruce stands** (L-5.4.f). Furthermore, the **tree species composition in natural forest reserves** (L-5.4.g) enables conclusions to be drawn about the course of adaptation processes in forest ecosystems with natural dynamics.

Sub-target 5.V (water retention): Water retention and storage in forest soils will be continuously improved by 2050

Forests play a vital role in large-scale water retention, both in helping to bridge longer dry periods and in absorbing larger amounts of water in the event of heavy rainfall. In particular, near-natural forests make an important contribution to erosion control, groundwater recharge and the resilience of the water infrastructure.

The **humus reserves in forest soils** indicator (L-5.5.a)[55] already used in the Monitoring Report on the German Strategy for Adaptation to Climate Change is suitable for measuring progress towards sub-target 5.V. A variant of the indicator that has been expanded and includes a soil hydrology component is planned to better reflect the target of improved water storage in forest soils. A water balance model is currently being developed to assess water availability and drought risks (TroWaK research project). It takes into account the factors of weather, tree species composition and soil, all of which are relevant for water availability.

Federal measures include water retention in forests under the Climate-adapted Forest Management funding programme (criterion 2.2.11), more dead wood, closed canopy and forest margins, as well as research and knowledge transfer into the practical application of the effects of various silvicultural measures on humus formation under different local conditions. It is important in the process to address climate risks and optimise the interactions between management, soil humus and soil moisture to achieve sub-targets 5.I, 5.IV and 5.V.

[55] The humus content of agricultural and grassland soils is addressed in the joint sub-targets of the soil and agriculture action areas (sub-target 0.I).

3.2.6 Outlook

Further details on targets or new measures and indicators may arise from ongoing relevant national and international processes (see Box 3 Targets, indicators and measures/instruments within the framework of other sectoral strategies, action programmes and EU regulations). Furthermore, targets and issues that are highly significant for the adaptation process and for evaluating the success of adaptation in the **land and land use** cluster were identified. However, due to a lack of underlying data, particularly in the area of measurability (indicators), they have not been included in the current proposed targets for the cluster. These include pest infestation, the diversification of trade relations for agricultural raw materials, the genetic diversity of wild species and indicators for wildlife refuges. The future development of corresponding indicators/indicator sets and basic data is therefore very important for identifying other important adaptation targets for precautionary climate adaptation, making them easier to measure, improving the accuracy of the information and monitoring progress towards achieving the targets.

Key measures in the area of future indicator development and further development are refining existing methods, testing new ones and improving the basic data, all with a view to all relevant types of land use. Remote sensing and artificial intelligence can provide important support in this context. Furthermore, the current monitoring programmes must be maintained, further developed, integrated and adapted so that the data required for the design and monitoring of adaptation measures can be provided. Potential land-use conflicts between different adaptation targets, but also in relation to other political goals, such as climate change mitigation, need to be discussed, categorised and evaluated from a policy perspective.

The goals formulated at EU level (see Box 3) must be contextualised and discussed at national level. Similarly, the Federal Government and the federal states need a coordinated approach, particularly with regard to data availability and the development of methods for monitoring and the practical implementation of measures to achieve climate adaptation targets.

For measures to be implemented on agricultural land, land use targets, for example for the biotope network, must be further incorporated into the nature conservation laws of the federal states and more fully included in their landscape framework planning. Jointly developed programmes and action plans can promote strategy development across institutional levels. In particular, when implementing measures on agricultural land, increased cooperation between different areas of responsibility is advisable. To this end, structural and human resources must be made available to ensure targeted, effective and long-term climate adaptation.

In agriculture and forestry, other stakeholder levels are important in addition to government actors, in particular farm managers, forest owners and the upstream and downstream value chain. To counteract barriers to implementation, the Federal Government and the federal states can continue to support implementation of individual measures through agricultural funding. However, the priority of government action must be to improve the information available to farms on climate impacts and adaptation options and their effects on the profitability of farms, as well as the infrastructure needed to provide the information.

3.3 Human health and care provision cluster

Ministry responsible for the cluster	Federal Health Ministry
Inter-cluster links	**Infrastructure** cluster **Urban development, spatial planning and civil protection** cluster **Water** cluster **Cross-sectoral action areas** cluster
Complete cluster paper	see Annex 1 (in German)

3.3.1 Significant risks: why we have to act

Climate change affects people's health and well-being in many different ways. Heat, in particular, is already considered in Germany to be a high risk of climate change for humans, as it has a major impact on human health, for example, by placing a strain on the cardiovascular system and often leading to a significant increase in deaths.

Furthermore, climate change in Germany can contribute to an increase in UV radiation exposure for humans and the risk of UV-related diseases, such as eye and skin cancer. Rising temperatures can also promote the spread of allergenic plants and their pollen (for example, *Ambrosia artemisiifolia*) and the spread of pathogens (for example, vibrios) and disease-carrying animals (for example, mosquitoes, ticks).

Although anyone can be affected by climate-related health problems or illnesses, there are groups in the population that are particularly vulnerable to the health effects of climate change. These include infants and small children, people who work outdoors, people with pre-existing conditions, the elderly and the homeless.

The targets and measures in the **human health and care provision** cluster address the following significant risks: **heat stress, UV-related health damage** and **allergic reactions to pollen**. Particularly serious effects on the health of Germany's population must be expected in these three areas. In addition, the **spread of potential disease vectors and the associated diseases**, with proven risks to human health, is linked to climate change. Vector-borne infectious diseases can be associated with high morbidity and mortality and cause considerable costs for the healthcare system. They will therefore also be considered here.

3.3.2 Targets, indicators and measures/instruments

The Federal Government has identified the following targets to counter the risks in the **human health and care provision** cluster:

Table 6: Targets in the human health and care provision cluster

Code	Target
G-1	Strengthen the public's ability to adapt to heat by 2030
G-2	Strengthen the public's ability to adapt to ultraviolet exposure by 2030
G-3	Strengthen the public's ability to deal with pollen allergies by 2030
G-4	Strengthen the public's ability to prevent and deal with infectious diseases facilitated by climate change, especially vector-borne diseases, by 2030

When selecting and implementing the targets, it must be ensured that the **federal states retain responsibility** for general public health services, including health promotion and prevention. A combination of preventative behavioural and structural measures is necessary to protect the population. In this context, preventative structural measures aim to change the framework conditions in healthcare, nursing and educational institutions and in municipalities. Where possible, the aim is to strengthen the abilities of local authorities to become even more active in adapting to the health consequences of climate change. In addition, the Federal Government is examining whether legal changes can be made to improve protection against heat and UV radiation. The issues of monitoring and research funding can also be considered. Where possible, synergies between targets must be leveraged, for example, in the targets for protection against heat and UV exposure. Some of the proposed indicators still need to be worked out in detail. It remains to be seen how they can be integrated into health monitoring and health reporting in Germany.

Target 1: Strengthen the public's ability to adapt to heat by 2030

The 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change shows that heat is already a particularly serious effect of climate change. High temperatures adversely affect human health. For example, heat can make existing cardiovascular, respiratory or kidney diseases worse, as well as directly causing heat-related illnesses. Furthermore, certain medications can have different effects during heat waves, which can negatively affect people's health. A significant increase in the number of deaths is regularly seen during hot periods. Most heat-related deaths occur in people aged 75 and over. Due to demographic change in Germany, the population as a whole is becoming more vulnerable to heat stress.

Since the very hot summer of 2003, various measures have been introduced in Germany to mitigate the health effects of high temperatures. Heat warnings issued by the German Meteorological Service, information and behavioural tips for people, especially vulnerable groups such as children, the elderly, the chronically ill and people with disabilities, and multipliers, and measures to protect against heat in health and care facilities and at municipal level, as a combination of preventative behavioural and structural measures, play an important role. These activities need to be expanded.

In this context, the target is formulated as ***strengthen the public's ability to adapt to heat by 2030***, with four sub-targets. Various indicators, some of which already exist and some of which still need to be developed, will be used to monitor progress towards the target. This is expected to be implemented as an interim target by 2025/2026.

Sub-target 1.I: Improve knowledge of the health effects of heat and appropriate behaviour

By 2030, significantly more people in the population say that they are aware of the health consequences of heat and have increased their awareness of heat-adapted behaviour than in the reference year, which has yet to be defined (most likely 2025/2026).

Indicators: to measure progress towards sub-target 1.I, new indicators for knowledge about the health consequences of heat (G-1.1.a) and knowledge about heat-related behaviour (G-1.1.b) must be developed and incorporated into the Federal Government's health monitoring and reporting system.

Sub-target 1.II: Increase in heat-adapted behaviour

By 2030, significantly more people say that their behaviour is adapted to heat (for example, with regard to fluid intake, providing shade in their homes and adapting daily routines). Progress towards sub-target 1.II will be measured using an indicator to record heat-related behavioural adaptation in the population (G-1.2.a).

Measures: to achieve sub-targets 1.I and 1.II, the Federal Government and, where appropriate, other levels or institutions, must carry out awareness-raising campaigns, and provide media and materials on behavioural adaptation for the population (especially vulnerable groups) and relevant multipliers (for example in healthcare, nursing and child-care facilities, educational institutions as well as in municipalities) (G-1.1), if necessary accompanied by preventative structural measures.

Sub-target 1.III: Strengthen the ability of municipalities to take measures, particularly preventative structural measures, to protect human health from heat in healthcare, nursing and child-care facilities and educational institutions

To measure progress towards sub-target 1.III, an indicator will be developed to measure the ability of municipalities to address heat as a health risk (G-1.3.a). Federal measures will be taken to strengthen the ability of the municipalities and healthcare, nursing and child-care facilities and educational institutions to promote heat-resilient environments and heat-adapted behaviour among the population (for example, through nationwide recommendations for action, good practices, awareness-raising) (G-1.2).

Sub-target 1.IV: Improve regular monitoring of heat-related mortality and morbidity

Monitoring will enable data on how heat affects the population to be provided quickly, also allowing trends to be identified at an early stage. This will make it possible to tailor health policy measures – in the healthcare system and public health service – directly and precisely in response. The heat-related mortality report that has been published weekly since summer 2023 will help by providing regular and timely data for the first time. The resulting indicators can be included in the health monitoring and reporting of the Federal Government, for example by the Robert Koch Institute.

Indicator: progress towards sub-target 1.IV will be measured by establishing relevant monitoring indicators/measures, for example, by expanding the scope of health monitoring and health reporting (to include heat-related hospital admissions) (G-1.4.a).

Target 2: Strengthen the public's ability to adapt to ultraviolet exposure by 2030

Ultraviolet (UV) radiation damages genetic material, is the main cause of skin cancer and is classified by the International Agency for Research on Cancer (IARC) in the highest risk group 1 as "carcinogenic to humans". According to estimates based on data from the Schleswig-Holstein skin

cancer registry, around 330,000 people in Germany are newly diagnosed with skin cancer every year. Anyone's health can be damaged by UV exposure. Children are particularly affected because their skin and eyes are more sensitive to UV radiation than those of adults. People who work outdoors and are exposed for particularly long periods are also at high risk.

The basic correlation between a change in UV radiation intensity and climate change is currently an important focus of research. Further information can be found in the complete cluster paper (see Annex 1 (in German)).

Although it is not yet possible to accurately predict the development of UV exposure and the associated onset of disease, the existing disease burden calls for effective measures to prevent UV-related diseases or at least to detect/diagnose them at an early stage. With this in mind, the ***target*** is formulated as: ***strengthen the public's ability to adapt to UV radiation by 2030***. The target is broken down into three sub-targets:

- **Sub-target 2.I: Increase knowledge of the negative health consequences of UV radiation**
- **Sub-target 2.II: Increase knowledge of effective preventative behavioural and structural protective measures**
- **Sub-target 2.III: Strengthen the ability of decision-makers (for example at municipal level) to address UV radiation as a health risk and establish appropriate protective measures**

Measures: multi-component programmes[56] tailored to the target group that address the health risks of UV radiation and preventative behavioural and structural protective measures must be developed, implemented and evaluated to achieve the target (G-2.1). In addition, the recommendations for action and preventative structural measures to prevent UV-related skin and eye diseases will be established, evaluated and optimised (G-2.2). Possible synergies, for example with heat protection measures, will be taken into account.

Indicators: the extent to which the target formulated here is achieved can be assessed based on the number (G-2.a), quality (G-2.b) and dissemination (G-2.c) of the multi-component programmes developed. Additional indicators include the number and quality of measures taken to provide shade for protection against UV radiation (G-2.d), the number, quality and frequency of UV index warnings in public spaces (G-2.e), changes in awareness of the UV index and its use to protect against UV radiation (G-2.f) and the quality and currentness of recommendations for action and measures to prevent UV-related skin and eye diseases (G-2.g).

In addition to the indicators that monitor the measures taken to achieve the targets, indicators must be developed and established to reflect the long-term development of UV-related diseases and how the population deals with these diseases. The legal framework for developing, establishing and optimising funding programmes for targeted financing of preventative behavioural and structural measures will also be examined.

Target 3: Strengthen the public's ability to deal with pollen allergies by 2030

Due to their high prevalence, allergies, especially those caused by airborne allergens (inhalant allergies), have become a very important aspect of public health. The reasons for this also include changes in environmental factors, where frequent contact with pollen, for example, can lead to pollen sensitisation and pollen allergies. The vegetation period has already changed noticeably as a result of climate change. Pollen counts generally vary from year to year, but peak concentrations,

[56] Multikomponenten-Programme sind bevölkerungsweite Programme, die Elemente einer individuell ausgerichteten Strategie mit strukturellen und politischen Maßnahmen sowie mit Medienkampagnen kombinieren.

such as those of birch pollen, now occur with increasing frequency. Due to climate change, the range of allergenic pollen in Germany will most likely continue to change – both with regard to native plant species and the spread of non-native plant species growing in the wild, such as ragweed (*Ambrosia*).

In addition to pollen levels, high temperatures and heat, coupled with poor air quality (for example due to air pollution or ozone), lead to an increase in the burden of disease, particularly among vulnerable groups (for example people with obstructive pulmonary diseases). The increase in the burden of disease manifests itself, for example, through an increase in symptoms, more visits to the doctor, more use of medication and a higher number of days of sick leave and hospital stays. In this respect, the **formulated target** is: ***strengthen the public's ability to deal with pollen allergies by 2030***. In particular, the aim is to increase knowledge about pollen allergies among the population and relevant multipliers. In explicit terms, this means that by 2030, significantly more people will say that they are informed about helpful measures for pollen allergies than in the reference year, which has yet to be defined (likely 2025/2026). The increase in knowledge will also be reflected in a change in behaviour: by 2030, significantly more people in the population will, for example, seek information about current pollen counts during pollen seasons, ventilate their homes properly, exercise correctly, take beneficial medicine, etc.

Measures: to achieve this target, the Federal Government and other institutions need to implement suitable awareness-raising measures for the public and for relevant multipliers (for example people working in healthcare, nursing and child-care facilities, educational institutions and municipalities). Pollen monitoring will be further developed (G-3.1).

It can be determined whether the targets have been achieved by integrating the indicators "Knowledge about helpful measures to deal with pollen allergies" (G-3.a) and "Behavioural changes to deal with pollen allergies" (G-3.b) into the health reporting system in Germany and collecting the relevant data.

Target 4. Strengthen the public's ability to prevent and deal with infectious diseases facilitated by climate change, especially vector-borne diseases, by 2030

In Germany, higher temperatures, especially mild winters and warm springs, as well as changing precipitation patterns, can affect the spread of infectious diseases. Examples include transmission of the West Nile virus by native mosquitoes, transmission of the Puumala hantavirus by bank voles, wound infections and gastroenteritis caused by non-cholera vibrios. In addition to climate change, globalisation, for example international tourism or global trade in animals and goods, also contributes to the spread of new vectors (such as the Asian tiger mosquito *Aedes albopictus* or ticks) and pathogens.

The most common vector-borne infectious disease in Germany is Lyme disease (*borreliosis)*, which is transmitted by ticks. The intensity and duration of the Lyme disease season are influenced by changing climate factors such as temperature and lack of rainfall. Both native and imported vector-borne infectious agents can lead to high morbidity and mortality and entail high costs for the health system. Vector-borne diseases are therefore an important public health issue. Prevention is very important, especially protection against infections for which there is no causal treatment, such as tick-borne encephalitis (TBE), which is also transmitted by ticks.

Against this background, the formulated **target** is to ***strengthen the public's ability to prevent and deal with infectious diseases facilitated by climate change***. To this end, knowledge, particularly with regard to vector-borne infectious diseases, their pathogens being transmitted by mosquitoes, ticks and bank voles, must be increased among the population and relevant multipliers, especially the medical profession. This means that by 2030, many more people will report being aware of infectious diseases facilitated by climate change, particularly vector-borne diseases, and of how to avoid such infections, than in a reference year that is yet to be defined (most likely 2025/2026). The increase in

knowledge will in turn lead to a change in behaviour: by 2030, significantly more people in the population will say that they have changed their behaviour to avoid vector-borne infectious diseases.

Measures: to achieve this target, the Federal Government and other institutions need to carry out suitable awareness-raising campaigns about vector-borne diseases for the public and for relevant multipliers, for example, in healthcare, nursing and child-care facilities, educational institutions and municipalities. Monitoring of infectious diseases and vectors will be further developed (G-4.1).

Indicators: knowledge about vector-borne diseases (G-4.a) must be included as an indicator in health reporting in Germany. Furthermore, an indicator for measuring behavioural adaptation to vector-borne diseases in the population can be developed to monitor progress towards the target (G-4.b).

Box 5: Existing initiatives, strategies and measures

In recent years, a number of initiatives, strategies and measures have been introduced to address the health impacts of climate change. These include, for example,

- the recommendations for the creation of heat action plans to protect human health published by the Federal Environment Ministry in 2017, which are aimed particularly at federal states and municipalities (www.bmuv.de/WS4443)
- the series of guides published since 2021 by the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection entitled "Den Klimawandel gesund meistern" (Climate change and human health)
- the educational and support information of the Federal Centre for Health Education (BZgA, www.klima-mensch-gesundheit.de)
- the Klimapakt Gesundheit (Climate Pact for Health) of the Federal Health Ministry (BMG) with representatives of the umbrella organisations in the health sector, the federal states and the municipal umbrella organisations
- implementation of the UV-safe campaign of the Federal Office for Radiation Protection (BfS) (www.bfs.de/uv-sicher)
- the Heat Protection Plan of the Federal Health Ministry from the summer of 2023 and its annual update, as well as the support offered to municipalities at www.hitzeservice.de.

In addition, the current state of research for Germany was summarised and made available to a broad audience in the new edition of the German Status Report on Climate Change and Health in 2023, with more than 90 authors. Furthermore, the Federal Ministry of Education and Research has been funding research projects on the interactions between human health and changes in biodiversity since 2023. These are often facilitated by climate change, such as the spread of disease-carrying vectors and allergenic plants.

3.3.3 Outlook

The current publications on the German Status Report on Climate Change and Health include a recommendation to integrate the principle of **Health in All Policies** even more fully into climate adaptation planning. The status report also identifies a general **need for research** into the link between climate change and human health. For example, it is often still difficult to establish a direct causal link between specific illnesses and climate change. Furthermore, there are gaps in research, particularly regarding the impacts of climate change on **mental health** and the development of a climate-resilient healthcare system.

According to the KWRA 2021, there is also a need for action with regard to the climate impacts of "**respiratory issues (due to air pollution)"** and **"effects on the healthcare system"**. New scientific findings and the measures already implemented as part of the strategy will be used to assess whether to include these issues in future. This is because many preventative behavioural and structural measures also affect the resilience of the healthcare system, for example, heat protection

plans in healthcare facilities. Furthermore, pressure on the healthcare system will be alleviated if the public adapts its behaviour to climate change. New research findings must also be incorporated and data sources expanded or newly developed when reviewing and adjusting the formulated goals, measures and indicators in the coming years and decades. In this respect, data on the link between climate change and human health and on the relevant targets and measures for adapting to the health consequences of climate change must also be significantly improved.

It would be beneficial if the **federal states and other relevant stakeholders** adopted the targets and measures and supported them in their individual areas of responsibility, for example by promoting health education, encouraging the use of shade in public spaces or in facilities to protect against heat and UV exposure, or by helping to improve the surveillance and monitoring of the indicators mentioned. In general, it would be advisable for the federal states and municipalities to pay particular attention to protecting human health when drawing up their climate adaptation strategies and plans, and to focus especially on the issues of heat, UV radiation, allergies and infectious diseases that are facilitated by climate change.

3.4 Urban development, spatial planning and civil protection cluster

Ministries responsible for the cluster	Federal Ministry for Housing, Urban Development and Building, Federal Ministry of the Interior and Community
Inter-cluster links	**Infrastructure** cluster **Land and land use** cluster **Human health and care provision** cluster **Water** cluster **Economy** cluster **Cross-sectoral action areas** cluster
Complete cluster paper	see Annex 1 (in German)

3.4.1 Significant risks: why we have to act

Future urban and spatial development must prevent or minimise the harm that climate change can inflict on people and the environment. In cities, this mainly means climate risks due to heat, drought and heavy rainfall. Rising maximum temperatures, tropical nights and longer heat waves in summer are exacerbating health risks, particularly in cities. This is due to the strain heat puts on people's circulatory systems, its negative impact on sleep, changes in the way medication works, etc., for example (see the **human health** action area) as a result of both higher outdoor and increasing indoor temperatures. Urban planning, efficient, compact and green land use designed for multiple uses and the relationship between development and providing municipalities with green-blue infrastructure is a decisive factor for heat stress and the water balance in urban areas. At the same time, heat and drought increase the stress on urban greenery. On the other hand, risks from heavy rainfall events in towns and cities are intensified by a further increase in the degree of sealing as a result of redensification processes (in particular, construction development, for example, to create affordable housing and transport infrastructure).

These climate risks pose challenges for urban, regional and spatial development and require good cooperation at the interfaces between the different spatial levels and policy areas. To this end, climate adaptation must also be given greater consideration in regional planning processes, for example by raising awareness among the responsible planning authorities. This will lead to new and updated spatial development plans that factor in climate adaptation as a criterion. The regional planning contributions to climate adaptation – taking into account the requirements of planning at federal state level – generally consist of designating, reserving or securing areas for those uses that can reduce potential damage and climate risks, particularly with regard to ecosystems (for example forests, soil, water bodies, grassland, cultural landscapes) and biodiversity, preventive flood protection and infrastructure (settlements, transport areas, energy infrastructure areas).

The stakeholders in the **civil protection and disaster response** action area support climate adaptation through many of their disaster risk reduction activities. But they themselves are also affected by the consequences. Extreme weather events such as heavy rainfall often cause damage to equipment and property and lead to significant staff absences and severe restrictions in the availability of critical infrastructure. In addition to these direct impacts, emergency services are often confronted with a very high volume of emergency calls and simultaneous incidents. They must also have additional capacities available to deal with relatively new challenges such as an often uncontrolled influx of spontaneous helpers or the spread of fake online reports about the incident. There is a danger that, as a result, these organisations will face severe staffing challenges in the short to medium term and will no longer be able to guarantee that they can reliably fulfil their duties to a

sufficient extent. In view of the changing security policy landscape, civil protection organisations must be able to deal with extreme weather events more effectively and efficiently than ever before.

3.4.2 Targets, indicators and measures/instruments in the urban and settlement development action area

The Federal Government is taking action to tackle the risks in the **urban and settlement development** action area using the following targets:

Table 7: Targets in the urban and settlement development action area

Code	Target
S-1	Activate urban green spaces to reduce heat stress
S-2	Achieve a more near-natural water balance for water-smart urban development

In the **urban and settlement development** action area, the focus is on settlements with more than 10,000 inhabitants. This is because small settlements are less affected by increased heat stress from urban development due to their low building density and/or size, and the need to address heavy rainfall and drought lies in other action areas (such as **buildings, water, land and land use**).

Target 1: Activate urban green spaces to reduce heat

The goal is to reduce the health risks posed by heat in particularly thermally stressed areas and in areas with heat-sensitive populations, and to improve the cooling capacity, accessibility and recreational function of urban green spaces and open spaces for urban residents.

The maintenance, further development and improvement of green infrastructure (such as parks, trees lining streets and greenery on buildings) is important for reducing areas with high thermal stress and the intensity of urban heat islands. Trees, particularly existing trees, are a very important part of green infrastructure. When planting vegetation, it is important to select climate-resilient, biodiverse and low-allergen plants. The quality of green-blue infrastructure is not determined solely by how much there is. Conversely, an adequate level of quality for the many functions can only be achieved through enough green-blue open spaces. To ensure that there is an adequate supply of green-blue infrastructure, planning must be integrated (taking into account the spatially relevant issues of buildings, green-blue infrastructure and mobility at the beginning of the planning process) and geared towards multifunctionality and the common good.

Indicators: the collection and calculation of the data for the proposed indicators is carried out by the Federal Government as part of its research activities and does not therefore entail any additional work for the municipalities. The **accessibility to cooling green spaces** indicator (S-1.a) (see box), which is intended to measure progress towards the target **activate urban green spaces to reduce heat stress** for all towns and cities with 10,000 inhabitants or more (S-1.a) (see box) is a heat-related variant of the existing **accessibility to urban green spaces** indicator (green accessibility for short) and is currently being developed. In priority areas (see below), the green volume indicator will also be used as a measure of greenery in these areas.

Accessibility to cooling green spaces is achieved when a publicly accessible, cooling green space can be reached easily by foot and can be used for cooling off during heat events close to where people live and/or work. Green spaces close to where people live and work are very important because of the relief they provide in hot weather, especially for socially disadvantaged and/or less mobile population groups. This also makes them an important element in socially just and fair cities.

The plan is to identify priority urban areas that have particular urban climate shortcomings due to their location (geographical, topographical) and structure (building structure, building materials, social structure).

The goal is to at least keep the indicator "Accessibility to cooling green spaces" **stable until 2030**. This applies to the broader urban area of all towns and cities with 10,000 or more inhabitants. In priority areas, the aim is to achieve an improvement starting in 2026. A minimum target will be set for the accessibility of cooling green spaces as a percentage of residents in these areas by 2035. Furthermore, the volume of greenery in these areas will be increased. This will result in more green space in these areas and reduce the high thermal load. The target values will be formulated as part of the update of the German Strategy for Adaptation to Climate Change and in consultation with the stakeholders involved, as soon as reliable values for the **accessibility to cooling green spaces** and the green volume are available and the priority areas have been determined through research.

Box 6: Measuring accessibility to cooling green spaces (indicator development)

To develop the **accessibility to cooling green spaces** indicator, the plan is to modify the **accessibility to urban green spaces** indicator (green accessibility for short) that is used in the monitoring conducted by the Leibniz Institute of Ecological Urban and Regional Development (IÖR-Monitor). In the IÖR Monitor, accessibility is determined in relation to the respective town, city or municipality. By contrast, the indicator to be developed will only be based on the percentage of the population that can reach a cooling green space on foot. In future, the plan is to also include recreational areas larger than one hectare. The extended perimeter of the town or city serves as the spatial backdrop. It includes the built-up residential area plus an additional 300 metres. This expanded scope includes the recreational areas directly adjacent to settlements.

To help create a cooling green space, the potential for evaporation and shade should be taken into account, for example, by the green volume. It measures the vegetation on green spaces (m^3/m^2) and indicates the above-ground volume of all plants growing on a surface, including building greenery. The larger the green volume in these spaces, the greater their effect on heat reduction during the day.

In addition, the cooling capacity of green spaces during the day compared to their surroundings can be used to describe the quality of a green space for preventing heat.

Target 2: Achieve a more near-natural water balance for water-smart urban development

The aim is to achieve a new approach to water management and minimise the risks posed by climate change due to the extremes of heavy rainfall and drought, as well as to activate evaporation cooling (water-smart urban development[57]).

In many settlement areas, the regulating ecosystem services provided by a near-natural water cycle, in conjunction with functional soils with vegetation, are severely limited by compaction, substructures, impermeable paved surfaces and artificial runoff paths. The water balance of surfaces that are paved with an impermeable layer is characterised by very high direct runoff, low water storage capacity and groundwater recharge and low evaporation. In addition, sealed surfaces heat up more than unsealed ones. This intensifies the impacts of extreme weather events such as heat waves, heavy rain and drought, which are becoming more and more common due to climate change.

[57] Water-smart urban development is defined as the design or redesign of built-up or planned areas with the aim of giving water in the city enough space and acknowledging its vital role, improving climate adaptation and quality of life. In addition to the advantages for climate adaptation, high-quality design and use can create added value for human health, recreation and social cohesion, as well as for biodiversity. The colloquial, descriptive term "sponge city" is often used as a synonym for water-smart urban development. It refers to the ability of a city's open spaces to absorb water like a sponge when it rains and to release this water again when it is dry to minimise the risks associated with extreme rainfall and dry periods, as well as to activate evaporation cooling.

Achieving a more near-natural water balance is therefore particularly important for climate adaptation. By creating more space for infiltration and water retention, the evaporation and cooling capacity of green-blue infrastructure can be increased, and the water availability for plants and their vitality can be improved. The precipitation water then serves as a resource for better soil health, which in turn promotes vibrant urban greenery. This will also increase the overall resilience of urban ecosystems and biodiversity. In addition, the water storage capacity in urban areas will be improved, helping to prevent the risks of heavy rainfall (flood prevention/protection). Achieving a more near-natural water balance is also a key component of water-smart urban development.

Indicator: due to the limited availability of data for systematically measuring components of the near-natural water balance in Germany (surface runoff, infiltration, evaporation), the **permeable surfaces** indicator (S-2.a) is used in the first step.[58] The aim is for the permeable surfaces of **settlements (in built-up residential areas) to at least be maintained, and in future increased**. In a second step, further components of the water balance will be included in monitoring. This indicator is related to the **soil sealing** indicator in the **land and land use** cluster. Over the course of the methodical development of the indicators, it needs to be determined to what extent the two indicators can use common data, with the aim of efficiently capturing the data.

The federal measures that will contribute to achieving targets 1 and 2 are broken down into legislation, funding, research and communication:

Legislative measures

- The Federal Government continuously strengthens and develops the legal framework for taking into account the transformation requirements of heat prevention and water-smart urban development (S-0.1). To this end, research will be conducted to analyse the possibilities for promoting climate-friendly urban development using new and existing legal instruments, and the results of this research will be taken into account in legislation where appropriate.

Funding measures

- The Federal Ministry for Housing, Urban Development and Building and the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection use and further develop their funding programmes to reduce heat and achieve a more near-natural water balance in cities (S-0.2).

Research measures

- Research to further develop the indicators and the calculation method and to improve the basic data for nationwide monitoring (S-0.3)
- Methodological research to identify priority urban areas that have particular urban climate shortcomings (S-0.4) due to their location (geographical, topographical) and structure (building structure, building materials, social structure)

The Federal Government (Federal Ministry for Housing, Urban Development and Building, Federal Institute for Research on Building, Urban Affairs and Spatial Development and other federal ministries) supports municipalities in developing green-blue infrastructure for heat prevention and in water-smart urban design through research by:

- compiling standardised basic data for the whole of Germany, such as accessibility to cooling green spaces and green volume, and making it available to towns, cities and municipalities on geodata portals, and by developing and providing digital tools (S-0.5)
- (further) developing standards and norms together with industry associations and developing standards/recommendations for analytical instruments such as a register for de-sealed areas and an accounting system for de-sealed areas (S-0.6), see also the **land and land use** cluster

[58] Permeable surfaces are defined as unsealed or partially sealed surfaces with a sealing degree of up to 30 percent.

- identifying the potential for and barriers to scaling up for broad implementation, for example, the spatial potential for climate adaptation, for greater connectivity of green spaces, for the preservation of existing trees and planting new ones (S-0.7)
- describing tools for implementing effective processes and measures for heat prevention through climate-friendly urban green spaces and for achieving a near-natural water balance in guidelines (such as recommendations for municipal open space statutes and processes for vital urban green spaces through water-smart urban design) and making them available to municipalities (S-0.8)
- carrying out model projects for testing innovative approaches (S-0.9), including better accessibility of public spaces (indoor and outdoor spaces) to keep cool, options for shade, the potential of areas of water in city centres and retention areas, multifunctional and floodable urban spaces and de-sealing
- developing recommendations for climate-adapted design in different types of settlements, as well as for the opportunities and limitations of nature-based solutions (S-0.10)

Communication measures

- Continuation of dialogue between the Federal Government and stakeholders on climate-adapted urban development (in particular federal states, municipalities, industry associations, the scientific community) in various formats (S-0.11), including in the context of the follow-up process for implementation of the White Paper on Urban Green (as part of the Agenda Stadt grün-blau (Urban Green-Blue Agenda))
- Increase in advisory, training and networking services (S-0.12)
- Awareness-raising among private stakeholders (especially housing associations, companies and stakeholders involved in the mobility transition) of the potential for climate adaptation (S-0.13) (especially greening, de-sealing and decentralised rainwater management).

3.4.3 Targets, indicators und measures/instruments in the spatial planning action area

The Federal Government is tackling the risks in the **spatial planning** action area using the following targets:

Table 8: Targets in the spatial planning action area

Code	Target
S-3	Develop and introduce climate adaptation monitoring (ex-post) for spatial development plans at the federal state and regional level at the Federal Institute for Research on Building, Urban Affairs and Spatial Development by 2026
S-4	Improve how future climate change impacts are taken into account when drawing up and updating spatial plans at the federal state and regional level by 2028

Target 3: Develop and introduce climate adaptation monitoring (ex-post) for spatial development plans at the federal state and regional level at the Federal Institute for Research on Building, Urban Affairs and Spatial Development by 2026

The aim of climate adaptation monitoring for spatial development plans is to summarise and present how specifications in spatial development plans for tackling the challenge of climate change are reflected and how these specifications develop over time, initially for four selected action areas (see text box below).

Box 7: Action areas for ex-post climate adaptation monitoring for spatial development plans

Based on ten action areas for climate adaptation with over 62 measures from guiding principles and action strategies for spatial development in Germany (Conference of Spatial Planning Ministers - MKRO - 2016) and the action plan for spatial planning on prevention, mitigation and adaptation strategies with regard to the spatial impacts of climate change (MKRO 2013), the following four action areas were selected as suitable for climate adaptation monitoring:

1. *Dealing with water shortages*
2. *Preventive flood protection in river basins, including carbon sinks*
3. *Protection against the effects of heat in settlement areas*
4. *Shift in the habitats of flora and fauna, including biotope networks*

The text documents of all spatial development plans in effect and all drafts to be further developed and updated throughout Germany are continuously recorded in the Spatial Plan Monitor of the Federal Institute for Research on Building, Urban Affairs and Spatial Development (ROPLAMO). ROPLAMO will be used to record, document and evaluate the extent to which climate adaptation targets are specifically incorporated into current spatial development plans at the federal state and regional level, and how these plans are further developed and updated. For the purpose of establishing benchmarks, the results of the KWRA 2021 will be taken into account when assigning the planning regions based on climate hotspots and other regionalised analyses. Furthermore, a methodology for determining standards will be developed that allows regional impacts and the need for regional adaptation to be aligned. In addition, there is a need for further specification and design of assessment criteria and of the evaluation system for plan evaluations with regard to:

- the inclusion of a regional vulnerability analysis
- the definition of specifications based on the need to protect the respective resources
- the use of adequate expert opinions and data as a basis for determining planning specifications that meet the requirements
- the nature (degree to which they are binding) of the specifications: target, principle; priority and restricted areas

Indicators: target 3 will be achieved with the introduction of climate adaptation monitoring (S-3.a) by the Federal Institute for Research on Building, Urban Affairs and Spatial Development. The indicators for climate adaptation monitoring have yet to be developed. The central measure of the Federal Government that will contribute to achieving target 3 is support for the development of the monitoring approach and suitable assessment criteria/indicators for measuring the progress achieved by spatial development plans (S-3.1).

Target 4: Improve how future climate change impacts are taken into account when drawing up and updating spatial plans at the federal state and regional level by 2028

When further developing or updating spatial development plans, greater consideration must be given to whether they include the foreseeable impacts of climate change, take into account the goals of climate change mitigation and contribute to the precautionary adaptation of land use to the impacts of climate change. Particular attention should be paid to the following:

- the contribution planning makes to the precautionary reduction of risks
- the use of opportunities arising from the impacts of climate change (adaptation strategies of planning)
- the identification of potential new risks by means of planning specifications

The Federal Government will support the responsible federal state authorities in formulating suitable criteria/indicators for better integration of these aspects and in developing vulnerability analyses by the authorities responsible. The aim is to promote climate-resilient planning that takes sufficient account of the future impacts of climate change and the necessary spatially relevant adaptation measures. These aspects must be taken into account in the existing procedural steps and must not delay drawing up federal state and regional plans.

Indicators still need to be developed.

Federal measures that will contribute to achieving target 4:

- Support for the development of criteria/indicators to better take account of the future impacts of climate change when drawing up spatial development plans (S-4.1). For the indicators that still need to be developed, it is particularly important to ensure that this does not delay drawing up the plans for federal state and regional planning.
- Development of methodological principles for vulnerability analyses with regard to regional climate scenarios: support for federal state and regional planning to determine the vulnerability of the planning area to the current and future impacts of climate change as a basis for assessing the degree of climate adaptation.
- Further development/update of the Klimawandelgerechter Regionalplan (Climate-friendly regional plan) (2016) and the web tool (https://klimreg.de) (S-4.2): to incorporate knowledge of the expected future climate changes in the respective planning area from data from various specialised policies and authorities.

3.4.4 Targets, indicators and measures/instruments in the civil protection and disaster response action area[59]

The Federal Government is tackling the risks mentioned in the **civil protection and disaster response** action area using the following targets:

[59] Civil protection is the generic term used to describe all the responsibilities and measures taken by municipalities and federal states in disaster response and by the federal government in civil protection. Since the targets and measures in this strategy are the responsibility of the Federal Government but still affect the disaster response of the federal states and municipalities, the generic term “civil protection” is used in most cases.

Table 9: Targets in the civil protection and disaster response action area

Code	Target
S-5	Expand the reach of warnings to the general public
S-6	Increase the level of public information and preparedness on the risks associated with climate change, in particular extreme weather events
S-7	Raise the visibility and attractiveness of volunteering in civil protection

The targets in the **civil protection and disaster response** action area are in line with the German Strategy for Strengthening Resilience to Disasters (Resilience Strategy). Risk-literate members of the public can assess dangers more realistically, and protect themselves and others, reducing the overall strain on emergency services. However, support is also needed from a pool of helpers that remains at least the same size, but ideally continues to grow. To ensure that the public receives reliable and timely warnings no matter where they are, the technical means of transmitting alerts must also be continuously developed.

Target 5: Expand the reach of warnings to the general public

Severe weather events such as the heavy rainfall and flooding in western Germany in summer 2021 have repeatedly highlighted the importance of providing the public with early and effective warnings. To be effective and prompt the right response, warnings must reach the public in time and be delivered through reliable technology. In Germany, the technical infrastructure is mainly provided by the Modular Warning System (MoWaS) that is operated by the Federal Office of Civil Protection and Disaster Assistance and made available to the federal states and municipalities for use. A number of warning systems are connected to this system, including public broadcasting, television stations, digital city billboards and the NINA warning app (emergency information and news app). An increasing number of municipalities are also once again providing permanently installed or mobile sirens, following additional funding for their purchase and installation. Furthermore, Cell Broadcast was rolled out as a new nationwide warning system in February 2023. This means that warnings can be sent directly to people's mobile phones.

Despite this broad coverage, there are still technical shortcomings in warning transmission. For example, it is still up to the user to install the NINA app, and in many municipalities, new sirens have yet to be installed or older ones reactivated. Particularly with regard to population groups that are considered to be especially vulnerable from a health, demographic and/or socio-economic point of view (for example people with disabilities, the elderly, poor and homeless), it is essential to use a wide range of analogue and digital warning tools in parallel because these groups cannot always be reliably reached by individual warning tools such as the warning app alone.

The overarching **target** for this area is therefore to ***expand the reach of warnings to the general public***. It is the responsibility of the Federal Government to expand the warning system infrastructure "insofar as the warning systems required for disaster response are insufficient for the purposes of civil protection" (section 6 (2) sentence 2 of the Federal Civil Protection and Disaster Relief Act (ZSKG)). This includes developing and maintaining the NINA warning app and providing funding to expand the siren network. Warning apps and sirens are among the warning tools with the greatest impact, so it is considered advisable to further increase their coverage as part of the corresponding sub-targets.

Sub-target 5.I: 30 percent increase in the number of NINA warning app users

Indicator to measure progress towards the target **"number of NINA warning app users"** (S-5.1.a). This is currently around 12 million (as at November 2024). The aim is to achieve a **30 percent increase in the number of users** (by around 4 million) **by 2030**.

Federal measures that will contribute to achieving sub-target 5.I:

- Implementation of the Nationwide Alert Day and support for similar events in the federal states (S-5.1)
- Information campaign to raise awareness of the different kinds of warnings, including the NINA warning app, in preparation for the annual Alert Day (provided budgetary resources are available) (S-5.2)

Sub-target 5.II: Expand the national siren network

Progress is reflected by an **upward trend** in the indicator "**Number of active sirens installed in Germany**" (S-5.2.a). The number is determined by the federal states with the help of the municipalities. To date (as at November 2024), around 38,000 active siren systems have been reported to the Federal Government, although not all of the federal states have submitted their figures yet. In addition to figures and information on other warning systems in Germany, a basic inventory of existing sirens is currently being compiled in a warning system register.

Federal measures that will contribute to achieving sub-target 5.II:

- Definition and documentation of a nationwide target structure of the siren network for civil protection (S-5.3)
- Continuation of the joint federal and federal state funding programme for sirens (S-5.4)
- Introduction of mandatory regulations for standardised siren signals (S-5.5)
- Further expansion of the warning system register and adaptation to current needs (provided budgetary resources are available) (S-5.6)

Target 6: Increase the level of public information and preparedness on the risks associated with climate change, in particular extreme weather events

A good level of information on the risks of climate change and ways for individuals to protect themselves is becoming increasingly important, especially given the increase in the frequency and intensity of extreme weather events. Personal preparedness and the ability of individuals to help themselves play an even greater role when a large number of deployments take place in parallel, when access routes are blocked and other restrictions are in place as a result of the incident, which means that it can take a long time for the emergency services to arrive.

This means that the ***level of public information and preparedness on the risks of climate change, including in particular the rise in the frequency and intensity of extreme weather events***, must be further increased. The proposed timeframe for achieving the target (2035) is slightly longer overall to make the measurement more resilient to fluctuations, as it is to be expected that the level of awareness will fluctuate, particularly in response to events that attract media attention.

Progress towards the target will be measured using three sub-targets:

- **Sub-target 6.I: 80 percent of the population is informed about the risks associated with climate change, particularly extreme weather events, that affect them**
- **Sub-target 6.II: 80 percent of the population is informed about options for protecting themselves in the event of a disaster, such as extreme weather events**
- **Sub-target 6.III: 80 percent of the population has taken sufficient personal precautionary measures to protect themselves from extreme weather.**

The targets will be achieved in stages, with the **interim target for 2030 set at 75 percent**.

As indicators and a basis for measuring progress, **figures from representative population surveys** will be used for all three sub-targets (S-6.a, S-6.b, S-6.c). The Environmental Awareness in Germany survey, which

is regularly conducted on behalf of UBA and the Federal Environment Ministry, would be useful for this purpose. It is currently being assessed whether the questions relevant for the sub-targets can also be added to a long-term study panel of the Federal Office of Civil Protection and Disaster Assistance in the near future. This would ensure continuity in data collection over a longer period of time.

Federal measures that will contribute to achieving target 6:

- Further development and broader distribution of the existing target group-specific information provided by the Federal Office of Civil Protection and Disaster Assistance on extreme weather-related dangers, precautionary measures and ways for individuals to protect themselves, also with a view to vulnerable groups and accessibility (S-6.1)
- Continuation of the information campaign "Für alle Fälle vorbereitet" (Prepared for any eventuality) (provided budgetary and staffing resources are available) (S-6.2)
- Agreement between the Federal Office of Civil Protection and Disaster Assistance and the German Fire Service Association (Deutscher Feuerwehrverband, DFV) and the Vereinigung zur Förderung des Deutschen Brandschutzes e. V. (vfdb) on cooperation in educating the public about extreme weather-related risks (S-6.3)
- Creation of information packages to support information work in municipalities (provided budgetary and staffing resources are available) (S-6.4)
- Expansion of networks with relevant stakeholders to better address vulnerable groups (S-6.5)

Target 7: Raise the visibility and attractiveness of volunteering in civil protection

The integrated assistance system of civil protection in Germany is largely supported by helpers in aid organisations, fire brigades and the Federal Agency for Technical Relief (THW). Around 1.7 million people volunteer their time to serve as civil protection and disaster response workers, receive training and are regularly deployed. Demographic change, the ongoing trend towards urbanisation and changing mobility patterns mean that the number of volunteers could potentially decline, particularly in rural areas. At the same time, the enormous influx of spontaneous helpers creates new potential, which needs to be harnessed in the long term through volunteering. That is why the **aim** to ***raise the visibility and attractiveness of volunteering in civil protection*** will be formulated and pursued.

Since no representative figures can be collected at national level on the number of people engaged in voluntary work, an activity-based indicator will be formulated and initially measured up to 2030: "number of federal formats and programmes to promote voluntary work in civil protection" (S-7.a).

Federal measures that will contribute to achieving target 6:

- Continuation of the volunteer campaign "Egal was du kannst, du kannst helfen" (It doesn't matter what you have to offer, you can help) (S-7.1)
- Continued operation and further development of the "Mit Dir für uns alle" (Working with you to help all of us) web platform, with a stronger focus on groups that have so far been underrepresented in civil protection voluntary work (for example women, senior citizens, immigrants) (S-7.2)
- Development of a programme for primary school education to raise awareness of volunteering in civil protection (S-7.3)

- Creation of a framework for the structured involvement of spontaneous helpers in civil protection under a joint Federation-Länder Working Group (S-7.4)
- Continuation of the Mobile Helfer (Mobile Helpers) project to recruit and coordinate unaffiliated and spontaneous helpers (S-7.5)
- Continuation of the annual funding prize “Helfende Hand” (Helping Hand) awarded by the Federal Ministry of the Interior and Community (S-7.6)

Another federal measure that will contribute to achieving targets 6 and 7 is the annual nationwide civil protection day organised by the Federal Government and the federal states (S-0.14).

3.4.5 Outlook

In the **urban and settlement development** action area, the compilation of data centrally by the Federal Government as part of its research activities can provide reliable and nationally comparable information that can serve as a basis for municipal planning and monitoring success. The federal states and municipalities can voluntarily supplement this basic data, especially if more precise and detailed data is available. The results of monitoring the indicators listed here will also serve as guidance for municipalities. They can be incorporated into climate adaptation plans, integrated open space development plans, urban land-use planning (land use plans and development plans) and municipal statutes (for example, tree protection or open space statutes) and serve as a basis for justification.

The federal states can also make a significant contribution to achieving the targets set out here. Federal state building codes are particularly important in this regard. These codes could, for example, enable local building codes relating to climate adaptation/climate change mitigation to be enacted. The federal state funding programmes can also contribute to achieving the targets and will be reviewed and, if necessary, adapted accordingly.

Other important stakeholders in achieving the target are housing companies and owners of private property. In their own interest and in the interest of tenants, these stakeholders can provide better shade in private green spaces in living environments as a precautionary measure against heat and heavy rainfall, for example by preserve existing trees. They can also increase the amount of greenery and level of biodiversity by planting robust vegetation that is adapted to the location and, as far as possible, native to the area, use the potential to de-seal surfaces and create room for rainwater retention. More potential can also be leveraged to de-seal road surfaces and integrate more greenery – these measures would also be eligible for funding from programmes of the Federal Ministry for Housing, Urban Development and Building and the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection. Universities and other stakeholders in further and continuing education can contribute to successful climate-adapted urban development, for example by integrating climate adaptation more into relevant courses of study such as urban planning, urban development, geography, spatial planning, landscape planning and urban water management, and by offering further training programmes for climate adaptation on a broad basis through further training institutions and industry associations.

In the **spatial planning** action area, further research and development is needed on the development and provision of improved regional climate data and regional climate projections for regional planning (for example, cold air dynamics, temperatures, bioclimate), including creating user-friendly, practical aids for regional and federal state planning and a uniform system for plan evaluation. Further research is needed into the conflict between the necessary density of a “compact” city that minimises the amount of land used for buildings, energy and transport, and the need to counteract this trend by providing ventilation and green spaces to ensure the urban heat island effect is not

intensified. Measurable indicators and new procedures and data sets are needed for climate adaptation measures to maintain and improve the supply of cold air/fresh air, thereby also protecting compensation areas. The same applies to indicators in the action fields **water shortage**, **flood protection** and **biotope area networks/habitats**.

The Federal Government will work with the federal states within the framework of the Standing Conference of Ministers responsible for Spatial Planning (Raumentwicklungsministerkonferenz, RMK) to achieve common targets. The federal states and Federal Government need to provide further information on implementation by the planning authorities (for example, tools, list of possible specifications for dealing with climate impacts, best-practice examples, contact people and information platforms). Effectively implementing climate adaptation measures requires stronger legal standards and instruments for urban planning. Individual regional pilot projects can create spaces for experimentation for the large-scale transformation. These can provide the space and freedom for a more consistent shift in priorities towards developing and protecting open spaces. In future, the Federal Government and federal states need to agree on the definition and provision of minimum criteria/content for risk and vulnerability analyses by the planning authorities.

In the **civil protection and disaster response** action area, further development will especially be necessary to achieve the target of increasing the range of warnings, particularly if there are ongoing changes in the way the public gets information. For this purpose, the use of digital radio networks (DAB+) for transmitting warnings will be evaluated in the coming years, and a long-term strategy for connecting new supplementary warning systems to the modular warning system will be developed. To establish the NINA warning app as a federal warning app in the medium to long term, the aim is also to get more federal authorities and ministries on board (for example, federal and federal state police forces, the Federal Office for Information Security, the Federal Office for Radiation Protection).

To achieve the target of increasing the level of information available to the public and personal preparedness, it will be necessary to examine in the longer term whether a national preparedness index can be established, in addition to the existing representative population surveys as a data basis, the development of which is currently still being reviewed along international lines.

Furthermore, it is important to discuss in the medium term to what extent the target of increasing the information and preparedness level can also be extended to critical infrastructure facilities, such as in the area of energy supply, water supply and disposal, or to organisations involved in emergency and rescue services (including disaster response). At federal level, there is already a range of information and advisory services for the target group of critical infrastructure operators; expanding these services would ideally further increase the resilience of critical infrastructure facilities, including their resilience to extreme climate events.

Successfully achieving the targets in civil protection also requires the active involvement of federal states, districts, municipalities and organisations involved in civil protection. All stakeholder levels are required to act as multipliers to ensure even broader dissemination of both information services to raise awareness of climate change-related risks and options for precautionary measures, as well as educational information about warnings, for example about the meaning of siren alert tones. Local public outreach is also a good way of recruiting volunteers. In addition to the distribution of information material, community activities and other participatory formats are particularly advisable as they enable people who are less likely to participate, such as immigrant communities, to take part in exchanging information at a low threshold level. Information campaigns at federal state level, which have already been conducted in some cases to raise awareness of volunteering, can effectively supplement the services and information offered at federal and local level and further highlight the need for individual action overall.

To increase the range of warnings issued to the public, further measures are needed in addition to the distribution of information about the available warning tools and how to use them. These

measures range from the technical development of warning tools and funding for their expansion to agreements or binding regulations between government agencies and warning tool operators. The federal states and municipalities will also need to continue to actively participate in documenting the number of siren systems and entering the figures in the warning system register. Only with a complete assessment of the situation can shortcomings be identified and remedied to substantially improve civil protection, including and especially from the risks of climate change.

3.5 Water cluster

Ministry responsible for the cluster	Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection
Inter-cluster links	**Infrastructure** cluster **Land and land use** cluster **human health and care provision** cluster **Urban development, spatial planning and civil protection** cluster
Complete cluster paper	see Annex 1 (in German)

3.5.1 Significant risks: why we have to act

According to the KWRA 2021 for Germany, there is an urgent need or a very urgent need for action in the action areas of water balance and water management and coastal and marine protection. On the one hand, in the case of strong climate change, much greater impacts as a result of climate risks are expected for water-related action areas by the middle of the century. On the other hand, water-related adaptation measures in some instances require a lot of time before they are implemented or become truly effective.

Much of this need for action results from surplus water volumes as a result of heavy rainfall and floods. However, growing risks of water shortage due to dry periods, for example low water levels in surface waters, changing availability of groundwater and the resulting decrease or seasonal variability in water availability, as well as deteriorating water quality, also make adaptation measures necessary.

In light of the climatological and hydrological changes, water withdrawals need to be reassessed and consideration given to how increased quality requirements and growing need for water in some sectors can be satisfied in future. At the same time, sectors that use water like agriculture are facing the challenge of adapting production to changes in water availability. Others sectors like shipping, energy, industry, as well as leisure activities, are also affected by low water levels and floods.

Coastal protection also plays an increasingly important role as the climate crisis worsens. Due to rising sea levels and the expected increase in the frequency of high water levels, Germany's coastal regions will be subject to an increased risk of floods in future.

3.5.2 Targets, indicators and measures/instruments

The Federal Government is tackling the risks in the **water** cluster using the following targets:

Table 10: Targets in the **water** cluster

Code	Target (short title)
Wa-1	Preserve available water resources for the long term – water balance and water management
Wa-2	Strengthen the resilience of the water infrastructure
Wa-3	Ecology – promote climate-resilient water bodies

In view of the wide range of challenges, joint targets have been drawn up for the action areas of **water balance and water management**, and **coastal protection**. As far as **marine protection** is

concerned, some groundwork is still required before suitable indicators and measurable targets can be identified. Possible targets for fisheries can be found in Box 8 at the end of section 3.5.2.

The targets, indicators and measures are based on the National Water Strategy and existing European directives like the Water Framework Directive[60] and the Floods Directive.[61] The federal states are responsible for enforcing these provisions in the water sector and implementing the Water Framework Directive. The Federal Government is responsible for federal waterways. As part of management planning, the federal states draw up programmes of measures that are binding for state authorities. These programmes list the measures required to achieve the objectives of the Water Framework Directive, good status for surface waters (ecological and chemical) and groundwater (quantitative and chemical). The competent authorities of the federal states are also responsible for flood protection and decisions on permits for water withdrawals.

Target 1: Preserve available water resources for the long term – water balance and water management

Terrestrially stored water has significantly decreased over the past 20 years. As a result, there has been a reduction in water resource availability in Germany.[62] This has to be seen in the context of an increase in water withdrawal by a range of sectors and in water needed for the environment. In the dry summers in 2018 to 2020 and 2022 there were frequent reports of restrictions on water withdrawal and conflicts over use.[63]

This is why **target 1** is formulated as: ***a sufficient supply of high-quality water is essential for humans and nature, and for people's social and economic activities. This valuable resource must be preserved for current and future generations.***

Target 1 covers all available water resources, both in surface waters and groundwater. It is broken down into four sub-targets and focuses on priority issues such as the widespread lack of specific information on the situation of groundwater bodies.

All four sub-targets are connected. For example, improved resilience of the agricultural water balance and stabilised groundwater resources are directly interdependent.

Sub-target 1.I: Stabilise groundwater resources – improve monitoring, modelling and forecasting

To preserve groundwater resources for the long term, it is necessary to set seasonal limits on groundwater withdrawals to a level adapted to the impacts caused by climate change, and to rigorously promote groundwater recharge. It is crucial to preserve groundwater resources for the long term, even though in Germany it can be assumed that as a result of varying temperatures and rainfall, the available groundwater will remain the same or, in individual cases, increase.

To achieve this, it is important to have comprehensive, national forecasts of available water resources, in addition to in-depth information about water resources currently available and actual groundwater withdrawals.

The existing indicator "Groundwater level and spring flow" (Wa-1.1.a) will be applied to measure progress towards sub-target 1.I, as already reported in the 2023 Monitoring Report on the German

[60] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.
[61] Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks.
[62] https://www.umweltbundesamt.de/daten/wasser/wasserressourcen-ihre-nutzung#die-wasserressourcen-deutschlands.
[63] see 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change.

Strategy for Adaptation to Climate Change. **The aim is to minimise the number of months with non-attainment of the mean minimum groundwater level/mean minimum spring flow (1971-2020).**

Measures to preserve groundwater resources and promote groundwater recharge in the landscape should be reflected, with a certain time lag, in the development of the indicator. In order to show the effects of (more tightly) controlled groundwater uses, the number of monitoring stations needs to be increased. These monitoring stations will be selected in consultation with the federal states when further developing the indicator.

Additional indicators are currently being developed:

- **The number of groundwater monitoring stations whose measurements are reported on a national information platform using uniform criteria** (Wa-1.1.b) (progress is reflected by an **upward trend** in the indicator)
- Number and scope of recorded, authorised and actual groundwater withdrawals (Wa-1.1.c) (measuring progress towards target): it is also important that the volumes that fall below the de minimis threshold of notification or authorisation that are withdrawn in the course of a year are also recorded Development of the indicator with the aim of recording actual groundwater withdrawals without giving rise to new reporting requirements, making use of available data where possible

Federal measures that will contribute to achieving sub-target 1.I:

- Improvement of forecasting capabilities of water balance analyses (for example, further development of climate modelling and regional groundwater models) and provision of scenarios for the development of water needs (based on analyses of water requirements) (Wa-1.I)
- Review of existing exemptions from the permit requirement for water withdrawals (Wa-1.2); in addition, review of whether to harmonise water withdrawal charges already imposed in 13 of Germany's 16 federal states
- Development of national standards for establishing an information platform to show the current groundwater levels (comparable criteria for data collection and presentation) (Wa-1.3)
- Establishment of a water register/further development of the water log to record authorised, applied for and actual groundwater withdrawals, including the volumes withdrawn (Wa-1.4)
- Establishment of a nationwide water balance accounting system in cooperation with the federal states, modelling (especially in areas with potentially conflicting uses), including the expansion of existing models to cover groundwater models (Wa-1.5)
- Greater and integrated use of GRACE satellite observations for more precise real-time monitoring of water movement underground, enabling tracking of the total storage volume of terrestrial surface waters and groundwater to facilitate improved assessment of the impacts of wet and dry periods for the agricultural water balance (Wa-1.6)
- Establishment of nationwide, representative groundwater withdrawal monitoring in cooperation with the federal states (Wa-1.7)

Sub-target 1.II: Adapt uses – minimise risk of overuse

As part of adapting water uses, water withdrawals can be reduced and/or timed differently, which can contribute to safeguarding water resources. Sustainable water management – also taking into account the impacts of climate change – aligns water availability and water demand, and helps

prevent deterioration of water bodies and overuse of water resources and therefore, for example, a drop in groundwater levels.

Precise knowledge and data on current water availability and water use, along with the best possible estimates of future availability and use, are essential to ensure that water use is more differentiated, sustainable and efficient and is the basis for preventing conflicts of use and overuse.

Progress towards sub-target 1.II will be measured by the existing indicator "Water use index" (Wa-1.2.a) already listed in the 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change. The indicator records water withdrawals in all sectors and presents them in relation to the long-term average of available water in Germany. **The German water use index has been below 20 percent, the internationally agreed threshold for overuse of water supplies and water stress, since 2007. It is important to ensure that the threshold value of 20 percent is not exceeded in the long term.**

The indicator "Water balance risk areas" (Wa-1.2.b) is currently being developed. On the basis of the water use index (see above), a regional indicator will be developed that also identifies the seasonal differences in water availability, water storage options and water use, and the development of water resources depending on (changing) climatic conditions.

Federal measures that will contribute to achieving sub-target 1.II:

- Method- and data-based further development of the water use index to determine water balance risk areas while closing gaps in data and taking account of the impacts of climate change (Wa-1.8).

Sub-target 1.III: Strengthen the resilience of the landscape hydrology

More water needs to be retained in the landscape in order to strengthen the resilience of the landscape hydrology. A range of adaptation measures will be implemented to achieve this sub-target, for example on agricultural or forestry land and in and around water bodies (see also **land and land use** cluster), and through decentralised water storage. De-sealing and, in particular, reducing land sealing in settlement areas and in agriculture is also an important issue in this context (see **urban and settlement development** action area and the **land and land use** cluster).

The existing indicator from the 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change "**Restoration of natural flood plains**" (Wa-1.3.a), progress on which is reflected by an upward trend, will be used to measure progress towards sub-target 1.III.

Additional indicators are currently being developed:

- Number and/or size of drained agricultural and forestry land (Wa-1.3.b) (progress is reflected by a **downward trend** in the indicator): measures to improve water retention include **reducing drainage of agricultural and forestry land where possible or managing drainage seasonally.** A survey of agricultural and forestry land drained as a result of construction measures (for example, drains, drainage ditches) will create a basis for further planning of measures. Systematic survey methods, for example with remote sensing, are still being developed.
- Documentation of the **number and/or size of rewetted peatlands** (Wa-1.3.c) (progress is reflected by an **upward trend** in the indicator): recording rewetted peatlands used for agriculture and forestry and unused near-natural peatlands also provides information about activities to restore near-natural landscape hydrology in a region (see **land and land use** cluster, sub-target 0.II on peat soils).
- **Number of days with critical soil humidity levels** (Wa-1.3.d) (progress is reflected by a **downward trend** in the indicator): soil humidity monitoring is carried out, for example, by the

German National Meteorological Service, and is made available with the soil humidity viewer in a nationwide overview – to date for arable land, grassland and forests. However, the soil humidity viewer is not currently suitable for depicting all measures for water retention. The indicator needs to be further developed in collaboration with other experts, in particular those working in the fields of forecasts and modelling the water balance.

- Number of logging extraction roads or paths per hectare of forest (Wa-1.3.e) (progress is reflected by a downward trend in the indicator): depending on the type of soil and weather conditions, damage to surface soil can have a negative impact on runoff. **The goal is therefore to reduce the number of logging extraction roads or paths** or to change their location, and at the same to choose soil-friendly methods for timber extraction (see **land and land use** cluster).
- Development of **areas of small standing water bodies** (Wa-1.3.f) (**Progress is reflected either by an upward trend in the indicator or the trend remaining the same**): small water bodies are important reservoirs for water in the landscape. Their water levels are being reduced as a result of climate change and draining measures. Development over time of natural small water body areas represents the landscape hydrology and can be captured with the aid of national satellite data.

Federal measures that will contribute to achieving sub-target 1.III:

- Spread of knowledge about the effectiveness of measures to improve water retention in the landscape and drawing up of suitable strategies and combinations of measures (Wa-1.9)
- Drawing up of guidelines for the regional, near-natural water balance (Wa-1.10)
- Promotion of implementation of section II.1.4 (reclaiming retention areas) of the Nationwide Federal Spatial Development Plan for Flood Protection at regional planning level (expert planning, planning at federal state and regional level, municipal level) (Wa-1.11)[64]

Sub-target 1.IV: Make water resource management viable for the future

The aim, by means of water supply plans, is to achieve a balance of interests between all user groups. Needs for action have to be recognised at an early stage and resulting conflicts avoided by taking appropriate measures. The top priority of water resource management in future will remain the supply of drinking water to the public. However, it is always crucial to take account of the water requirements of ecosystems. The goal is to establish nationwide water supply plans that are founded on uniform minimum standards as instruments to make water resource management viable for the future. These plans also need to take account of the impacts of climate change and contribute to ensuring that the water supply becomes more resilient. In addition to content-related minimum requirements, it is also important to ensure that the strategic aspects of different planning levels (supraregional, regional) are consistent with one another. This is essential in order to harmonise the wide range of competing claims for use, for example from upstream and downstream users along rivers.

In order to measure progress towards sub-target 1.IV, the indicator "**Share of land areas in Germany for which water supply plans have been drawn up**" (Wa-1.4.a) is currently being developed. It will determine the current state of development of water supply plans. Progress is reflected by an **upward trend in the indicator**.

[64] Verordnung über die Raumordnung im Bund für einen länderübergreifenden Hochwasserschutz (BRPHV), Federal Law Gazette Part I No. 57 of 25 August 2021.

Federal measures that will contribute to achieving sub-target 1.IV:

- Establishment of nationwide uniform criteria and development of guidelines for drawing up water supply plans (Wa-1.12)
- Implementation of regional, integrated water management plans that define sustainable and cross-sectoral use of water in rural areas, including agriculture (Wa-1.13)

One federal measure that will contribute to achieving sub-targets 1.II and 1.IV is the establishment of guidelines for prioritising water uses in times of water shortages and for dealing with conflicts of use (Wa-1.14).

Target 2: Strengthen the resilience of the water infrastructure[65]

In the case of existing water infrastructure and when planning durable infrastructure, it is important to ensure that its design makes it more climate-resilient and adaptable. This applies in particular to infrastructure for drinking water supply and wastewater disposal, and infrastructure for flood protection, low water management and coastal protection. In addition, physical infrastructure to protect against flooding and heavy rainfall also needs to be upgraded. Dam management can also contribute to resilience, for example of supply systems, and therefore to adaptation to climate change.

This is why **target 2** is formulated as: ***design the water infrastructure in a way that can be adapted with as little effort as possible to changing conditions such as the advancing climate crisis, to changing public demands for higher ecological standards or the changing water needs of users.***

Explanation: *The infrastructure is – wherever possible – designed in the form of nature-based solutions. It is important to find a balance between technical and nature-based solutions to strengthen, expand or modernise water infrastructure that harness the potential of linking water, energy and material cycles and that are networked at the appropriate intermunicipal level.*

Sub-target 2.1: Ensure climate-adapted design of water infrastructure

By carrying out a climate check it is possible to evaluate resilience and climate-adapted design. This is possible for every type of water infrastructure. The resulting adaptation can, for example, be a climate surcharge in the planning stage, water-saving design of infrastructure or a construction process that increases the stability of a construction in cases of extreme flooding.

The expected impacts of climate change are already being taken into account in many federal states in the planning and construction of new flood and coastal protection measures. There are further examples at the Federal Waterways and Shipping Administration (climate adaptation process) and for measures under the Water Framework Directive.

In future it will be important to develop a process for taking the impacts of climate change into account and for assessing climate resilience, adaptive capacities or requirements for other water

[65] The Federal Government has been funding flood and coastal protection since entry into force through the Joint Task for the Improvement of Agricultural Structures and Coastal Protection (GAK). Due to its major significance, the Federal Government reimburses up to 70 percent of coastal protection expenditures incurred by the federal states. (The Federal Government contributes to financing measures to create more room for watercourses under the National Flood Protection Programme and all other GAK measures with up to 60 percent of the expenditures of the federal states). The federal states decide for themselves on the scope and specific form of the funding options set out in the GAK framework plan. They are also responsible for administering funding.

infrastructure (including impoundments for hydropower or drinking water abstraction, drinking water treatment plants, hydropower installations).

The following indicators are being developed to measure progress towards sub-target 2.I:

- **Number of water infrastructure systems that use climate surcharges or were adapted to increased flood runoff caused by climate change** (Wa-2.1.a) (progress is reflected by an **upward trend** in the indicator)
- **Number of water infrastructure projects for which a climate check was carried out during planning, in relation to the total number of projects** (Wa-2.1.b) (progress is reflected by an **upward trend** in the indicator)
- **Proportion of water management projects that apply nature-based solutions** (Wa-2.1.c) (progress is reflected by an **upward trend** in the indicator): it is assumed that nature-based solutions are beneficial as an adaptation measure because they are considered to be effective across a broad spectrum and can be flexibly adapted. **They also facilitate synergies with other sustainability targets.** The goal should therefore be to measure the proportion of projects applying nature-based solutions. With regard to the German Strategy for Adaptation to Climate Change, there is still a need for a practical approach to identifying measures as nature-based solutions.

Federal measures that will contribute to achieving sub-target 2.I:

- Adaptation of (technical) water regulations to climate change (Wa-2.1)
- Improvement of current knowledge about climate surcharges used in Germany and review of the need for a nationally harmonised method to determine and implement appropriate climate surcharges (Wa-2.2)
- Identification of how often nature-based solutions are planned and used; review of existing methods to identify nature-based solutions and adopt them where appropriate (Wa-2.3)
- Research on the effectiveness of nature-based solutions for climate adaptation and suitable combinations of measures, in settlements taking into account a high quality of use and design, in order to harness synergies between climate adaptation and quality of life resulting from nature-based solutions to the greatest possible extent (Wa-2.4)
- The Nationwide Federal Spatial Development Plan for Flood Protection (Annex to section 1 of the Ordinance on the Nationwide Federal Spatial Development Plan for Flood Protection (Verordnung über die Raumordnung im Bund für einen länderübergreifenden Hochwasserschutz)), I.2.1 (Z)) requires the water sector and spatial planners to take account of the impacts of climate change and to reflect them in existing and spatial planning (Wa-2.5)

Sub-target 2.II Minimise damage caused by heavy rainfall – raise awareness of the hazards and risks of heavy rainfall

The creation and publication of maps indicating the hazards and risks of heavy rainfall and flash flooding are an important basis for developing measures to protect against local flooding and damage caused by heavy rainfall. These maps provide information on risks, contributing to more effective precautionary measures to tackle the impacts of climate change.

On the basis of criteria that the federal states already use in some cases to draw up maps for heavy rainfall, and including the national heavy rainfall warning map that will be available in 2025, nationally uniform criteria and methods will be identified for drawing up municipal heavy rainfall hazard and risk maps.

The following indicator is currently being developed to measure progress towards sub-target 2.II: "**Number of cities, towns and municipalities that have drawn up municipal heavy rainfall hazard and risk maps" (Wa-2.2.a)** (progress is reflected by an **upward trend in the indicator)**.

Federal measures that will contribute to achieving sub-target 2.II:

- Establishment of a legal requirement to create and publish hazard and risk maps for protection against local flooding after heavy rainfall events (Wa-2.6)
- Creation of hazard maps for flooding caused by heavy rainfall events and, where required, updates to existing inventory maps, detailed local assessments of risk areas and, where necessary, creation of site-specific local maps (Wa-2.7)
- Establishment of heavy rainfall risk management, for example in the form of municipal planning of measures to reduce hazards and risks (see also **land and land use** cluster (Wa-2.8)

Target 3: Ecology – promote climate-resilient water bodies

Less water, extreme dry periods, rising temperatures, increased solar radiation and more frequent extreme events are leading, among other things, to extreme pressure on the ecology of water bodies.

Sub-target 3.I: Systematically improve water body structure

To make surface waters resilient to the impacts of climate change, heavily modified water bodies with monotone hydromorphological structures must be developed back into near-natural or natural water bodies by means of structural measures. It is important to take into account the needs of infrastructure, agriculture, flood protection, the energy industry and other uses. This will encompass measures that give water bodies more space, promote typical riverbank vegetation and improve water body floor structures, including the restoration and reconnection of floodplains.

The existing indicator **"Share of structurally non-modified and slightly modified water body sections** (water body structure category 1-3) (Wa-3.1.a) will be used to measure progress towards sub-target 3.1 (progress is reflected by an **upward trend** in the indicator). This WFD indicator gives a percentage of how many surface water bodies have a good morphological structure. The higher this number, the more likely it is that the water bodies will be resilient to the effects of climate change and can provide habitats for aquatic organisms.

One indicator being developed is the **"Share of the water body section for which development measures have been implemented"** (Wa-3.1.b) (progress is reflected by an **upward trend** in the indicator): there is a need to classify water body development measures in a way that is suitable for reflecting both an increase in smaller water body development measures and for large and comprehensive measures in the development of the indicator.

Federal measures that will contribute to achieving sub-target 3.I:

- Communication between federal states on the basis of uniform climate indicators on water body structure to provide a basis for optimisation of climate impact monitoring – existing instructions for mapping from the federal states, based on the provisions set out by the German Working Group on water issues of the Federal States and the Federal Government, should be harmonised to make them easier to evaluate (Wa-3.1)
- Establishment of a legal requirement and promotion of specific water body development corridors for naturally dynamic hydromorphological water body development (Wa-3.2)
- Creation of a funding programme for dismantling transverse structures in watercourses as part of the Action Plan on Nature-based Solutions for Climate and Biodiversity (Wa-3.3)

Sub-target 3.II: Stabilise the temperature of water bodies

Water temperatures are expected to increase due to climate change. Additionally, anthropogenic inputs, for example of cooling water and wastewater, also affect water temperature. Water temperature determines the physico-chemical conditions and is therefore extremely important for water-dependent animals and plants.

The existing indicator **"Water body temperature"** (Wa-3.2.a) will be used to measure progress towards sub-target 3.II. The indicator should be monitored and, based on a reference period yet to be determined, progress is reflected by a **slight upward, unchanged or downward trend in the indicator**. The data available on water body temperature is very good as it is recorded almost every time a sample is taken and, in the case of larger water bodies, is even continuously recorded at permanent monitoring stations. This makes it possible to identify trends for this indicator. The indicator **"Share of shady sections of water bodies"** (Wa-3.2.b) is being developed; **progress is reflected by an upward trend in the indicator**. Providing shade for small and medium-sized water bodies using suitable riparian vegetation is one possible adaptation measure to stabilise the temperature of water bodies. For this indicator it is essential to discuss, develop and test options for harmonised collection and evaluation across all federal states.

Federal measures that will contribute to achieving sub-target 3.II:

- Creation of suitable conditions, for example in the framework of funding, for easier cultivation of suitable riparian vegetation along water bodies, banks and buffer strips (Wa-3.4)
- Cultivation of suitable riparian vegetation typical to water bodies to provide shade for vulnerable small and medium-sized water bodies (Wa-3.5)

Sub-target 3.III: Identify and designate vulnerable sections of water bodies throughout Germany

Low water levels in rivers and dried-up water bodies pose an ecological challenge when it comes to climate adaptation. Measures that limit the ecological impacts of low water levels include a structurally varied design of water bodies and management measures that, for example, reduce water withdrawals.

In order to give these measures a scientific basis and ensure that they are systematically implemented, an evaluation system is required that is comparable throughout Germany and that enables the identification of sections of water bodies that are at risk of low water and vulnerable to drying out. The federal states have started to develop such evaluation systems and a nationwide uniform procedure for the ecological evaluation of low water levels**.**

The following indicators are being developed to measure progress towards sub-target 3.III:

- **Share of vulnerable sections of water bodies in the network of water bodies** (Wa-3.3.a) (progress is reflected by a **downward trend** in the indicator)
- **Number of water gauges with suitable measurement of low water levels** (Wa-3.3.b) (progress is reflected by an **upward trend** in the indicator): in order to create an adequate data baseline, the number of water gauges that can still provide data during low water levels must be reviewed and, if necessary, increased; in other words, gauges that remain in continuous contact with the water body
- **Number of retreat areas in times of low water levels** (Wa-3.3.c) (progress is reflected by an **upward trend** in the indicator)

These indicators require the availability of a nationally comparable assessment system. Only then will it be possible to assess whether the indicators are sufficiently sensitive to react to

successfully implemented adaptation measures.

Federal measures that will contribute to achieving sub-target 3.III:

- Introduction of nationwide uniform criteria to identify sections of water bodies vulnerable to low water levels/water shortage (Wa-3.6)
- Designation by the federal states of sections of water bodies vulnerable to low water levels/water shortage (Wa-3.7)
- Identification of vulnerable sections of water bodies where WFD measures can contribute to improving water body structure (Wa-3.8)
- Implementation of nature-based solutions that also strengthen the resilience of watercourses to climate change and that contribute to natural flood protection (measures 2.2 – 2.4, 8.5 and 8.7 in the Action Plan on Nature-based Solutions for Climate and Biodiversity) (Wa-3.9)
- Development of a nationwide procedure for the ecological assessment of low water levels, taking into account relevant parameters (such as water levels, water temperature and, where applicable, further physico-chemical parameters (Wa-3.10).

Box 8: European targets for the fisheries sector

The fisheries sector covers sea fishing, fishing in inland rivers and lakes and, depending on the definition, aquaculture. In Germany, the federal states are responsible for inland fishing and aquaculture and the Federal Government is responsible for sea fishing.

However, fisheries policy and the associated legislation for European marine waters is organised solely at EU level. In other words, fisheries policy does not accommodate any independent national scope for action. All targets and measures of the EU's Common Fisheries Policy and the legal acts required to implement them are fully transposed in the EU Member States. This is why no national adaptation targets are set for fisheries. Instead, European adaptation targets are used.

One key objective of the Common Fisheries Policy (Regulation (EU) No 1380/2013) is **management of all fish stocks to the level of the maximum sustainable yield** (MSY) (Art. 2(2) of Regulation (EU) No 1380/2013). Management at MSY level ensures that fish stocks are managed sustainably and are productive and as resilient as possible to fishing and other stress factors like climate change.

In addition to regular adjustment of catch quotas in line with the MSY targets, fleet capacity is regularly reviewed in the framework of the CFP and adjusted in line with the fishing opportunities available according to the MSY (Art. 22 Regulation (EU) No 1380/2013). The European Commission publishes annual reports on the state of jointly exploited fish stocks and fleets, and on achievement of CFP targets. These reports serve as a basis for adaptation measures in fisheries policy. EU Member States will provide the relevant data, indicators and reports on the economic state of the fishing fleets and on the balance between fishing opportunities and fishing capacity – including in relation to climate change. The balance-related indicators used are (for details, see EU Document COM(2014)545):

Biological indicators:

- Sustainable harvest indicator: "overfished" is assessed with reference to fishing mortality rates over time (FMSY values) and reliance of the respective fleet segment is calculated in economic terms
- Stocks-at-risk indicator: number of biologically vulnerable stocks per fleet segment

Economic indicators:

- Return in investment: long-term profitability of the fishing fleet segment compared to other available investments
- Ratio between current revenue and break-even revenue
- Technical indicators (vessel use)
- Proportion of vessels that are not active
- Active vessels: average activity levels of vessels that fished at least once in the year

3.5.3 Outlook

There is still considerable need for research, especially regarding the development of indicators. Data availability, monitoring and modelling are important areas of research. The National Water Strategy also specifies research requirements at the level of measures.

As far as marine protection is concerned, some groundwork is still required before suitable indicators and measurable targets can be identified. In the long term, this action area could be a greater focus if usable findings are available from the Action Plan on Nature-based Solutions for Climate and Biodiversity and from research and development projects on the nexus of climate and oceans. In particular the overlaps with water issues in the action areas and (sub)-clusters **land and land use**, **urban and settlement development**, **infrastructure** and **buildings** should also be well coordinated during further development. It is important to make use of the overlaps with existing plans and strategies. The development of a target for fisheries and its position in the strategy will be reviewed when the strategy is updated.

Implementation of all climate adaptation measures, and in particular those of the National Water Strategy, can only be achieved in broad cooperation processes between the Federal Government, federal states, municipalities, industry and the public. One focus is on continued close cooperation between the Federal Government and the federal states, for example in the German Working Group on water issues of the Federal States and the Federal Government and in the further expansion of cooperation on data collection and provision, and on the nationwide implementation of directives that contribute to the protection and fair distribution of water as a resource.

3.6 Economy cluster

Ministry responsible for the cluster	Federal Ministry for Economic Affairs and Climate Action
Inter-cluster links	**Infrastructure** cluster **Urban development, spatial planning and civil protection** cluster **Cross-sectoral action areas** cluster
Complete cluster paper	see Annex 1 (in German)

3.6.1 Significant risks: why we have to act

The inevitable impacts of climate change are affecting companies and their competitiveness in a number of ways, making them increasingly vulnerable. Even if the economic consequences and risks of climate change for companies are difficult to quantify, the causal relationships can still be clearly described.

The increasing frequency and intensity of damaging events, such as flooding, heat waves and heavy rainfall, pose a direct threat to production sites and business assets, both in Germany and abroad. Extreme weather events can also affect the functionality of supply chains. Disruptions to suppliers' production and transport routes can have a significant economic impact on companies. Furthermore, damaging events in a company's sales markets can negatively impact its earnings. In extreme cases, changing climate conditions can even jeopardise entire business models. Transitory risks resulting from climate policy are also relevant for companies as an indirect impact of climate change and must be taken into account when identifying the need for adaptation and implementing adaptation measures.

For companies, the changing climate will bring not only the risks described but also economic opportunities. Innovative products and services created in response to climate-related changes in demand hold additional potential for growth and value creation. An integrated approach to transformation processes presents an opportunity to create and harness synergies with other aspects of sustainable economic development (climate change mitigation, circular economy, etc.). By proactively adapting, companies can not only minimise risks but also develop and take advantage of additional market opportunities. A precautionary and proactive adaptation strategy must take both aspects into account and address them in the **economy** cluster.

3.6.2 Targets, indicators and measures/instruments

The Federal Government has identified the following targets based on the vision for the **economy** cluster as a means of countering the risks identified for this cluster:

Table 11: Targets in the economy cluster

Code	Target
Wi-1	Analysing physical climate risks is an integral part of corporate risk management
Wi-2	Analysing physical climate risks is an integral part of investment decisions
Wi-3	Extreme weather events no longer lead to significant losses due to the impacts on company staff and assets in Germany
Wi-4	German companies can operate successfully on national and international markets with technologies and services in the context of climate adaptation and continuously increase their aggregated added value in line with the trend

It is not yet possible to identify any measurable sub-targets in the **economy** cluster. The first step is to clarify fundamental issues related to data collection and availability. For this reason, potential sub-targets for the above targets would not currently meet the criterion of measurability. However, establishing the necessary conditions for underpinning the targets and associated sub-targets with indicators when the strategy is updated in future must be pursued at an operational level in the coming years (see Outlook section).

Box 9: Vision and missions for the Federal Government's climate adaptation policy in the economy cluster

In view of the need for action, the following **vision** is formulated, which serves as the basis for the targets to be developed and as a communicable framework for adaptation policy in the **economy** cluster:

In 2045, Germany has a climate-resilient economy with all stakeholders at all levels ensuring comprehensive adaptation to the unavoidable impacts of climate change. All economically relevant decisions are made with strategic consideration of the impacts of climate change. To ensure the support of the general public for adaptation measures, it is crucial that implementation be economically viable and proportionate, without disregarding the long-term effects of inadequate climate adaptation. Decisions are made to ensure that companies make the best use of the economic opportunities that arise, including in international markets, and find cost-effective solutions to minimise relevant climate risks.

The starting point for defining the role of the Federal Government is the fundamental understanding that adapting to climate change, reducing vulnerability to the impacts of climate change and taking advantage of new market opportunities are in the genuine interest of private sector stakeholders. It follows that the overall role of government is to enable and support the process of achieving a climate-resilient economy. This role is an acknowledgement that the Federal Government itself cannot create a climate-resilient economy. Furthermore, requiring private sector actors to take climate-resilient action would hardly be feasible on a broad scale, nor could it be monitored with reasonable cost and effort. In the context of the Federal Government's efforts, the involvement of intermediaries such as trade unions, chambers of trade, chambers of industry and commerce, business associations, the credit industry and insurance industry is crucial to raising companies' awareness of climate risks and potential for adaptation and supporting them in implementing measures.

Based on these considerations and the vision of a climate-resilient economy, the following **missions** define the mandate of the Federal Government's climate adaptation policy in the **economy** cluster:

1. ***Ensure that information is provided and awareness raised****: companies and financial actors must be made aware of physical climate risks and the possibilities for adaptation to climate change in their own area of activity*
2. ***Strengthen the resilience of companies****: support is provided to companies to minimise economic and financial losses caused by climate change and to reduce their vulnerability to climate-related damage*
3. ***Support climate adaptation industry****: support is provided to harness new market opportunities that arise from climate change so that German companies can successfully operate in national and international markets with technologies and services in the context of climate adaptation; one of the key starting points here is to create the best possible conditions for companies*

The **economy** cluster includes industry, construction, distributive trades and services in general and the financial sector. The focus is particularly on industry, which is directly and indirectly affected by the various impacts of climate change due to its international interdependencies. It is characteristic of the **economy** cluster that the government does not play a planning or operational role here. Adaptation to the inevitable impacts of climate change is primarily the responsibility of private sector stakeholders and companies.

The targets are each assigned to one of the missions mentioned (see box in section 1), which are aligned with the vision's timeframe of 2045. The targets need to be reviewed and, if necessary, revised in the planned updates.

The following federal measures will contribute to achieving targets 1-4:

Update the Federal Economics Ministry's 2014 climate check tool for industry and medium-sized enterprises (Wi-0.1): since 2014, the Federal Government has provided a low-threshold, online-based tool for companies, particularly in industry and medium-sized enterprises. This tool performs a rudimentary check to determine the extent to which the companies are affected by the impacts of climate change. The Federal Government is considering updating this tool and developing suitable communication formats to make companies even more aware of this tool.

Assess the possibility of establishing an advisory centre for companies based on the Centre for Climate Adaptation for municipalities and social institutions (Wi-0.2): companies currently often lack the expertise to adapt. Particularly for small and medium-sized enterprises (SMEs), the development of risk analyses and adaptation plans already represents a major challenge. A practical information and advisory centre for companies could provide valuable support for the internal development of analyses, strategies and implementation plans in the context of climate adaptation. The Federal Government is considering setting up a centre of this kind in consultation with the leading industry associations. Experiences with the existing Centre for Climate Adaptation and services at the federal state level must also be taken into account and synergies leveraged.

Review whether to create a standard for climate adaptation advisory services (Wi-0.3): standards can be an effective tool for helping achieve corporate climate adaptation targets. There are currently no uniform and binding standards for climate adaptation advisory services. Standardisation, particularly when it comes to training climate adaptation advisers, is a suitable way of assuring quality in this segment and creates the conditions for being able to promote climate adaptation advisory services in future.

Review federal funding for climate adaptation advisory services (Wi-0.4): as soon as there are established standards for advising companies on climate adaptation, the Federal Ministry for Economic Affairs and Climate Action will review federal funding for climate adaptation advisory services.

Mainstream climate adaptation in national strategies with relevance for economic policy (Wi-0.5): in future, the Federal Government will mainstream climate adaptation when developing and updating strategies related to economic policy. This will ensure that the issue enjoys greater visibility and that adaptation to the impacts of climate change is taken into account in all relevant strategies and measures.

Assess the integration of climate adaptation into existing funding programmes (Wi-0.6): the Federal Government will assess the extent to which climate adaptation issues can be integrated into existing funding programmes. A funding bonus for adaptation-related activities and additional activities eligible for funding will be considered subject to the available budgetary resources.

Step up dialogue on climate adaptation with industry associations and stakeholders in existing dialogue formats (Wi-0.7): existing dialogue formats with companies and industry associations, for example as part of the Alliance for the "Future of Industry" and the Industry 4.0 platform, will be used more in future to discuss ideas with industry associations on various aspects of adaptation to the impacts of climate change.

Assess the merits of a stronger business component in the Blue Compass climate adaptation management award (Wi-0.8): the Federal Government is reviewing whether the Blue Compass climate adaptation management award can be expanded to include an award segment that is even more heavily focused on companies and various corporate adaptation activities. Alternatively, it will be considered whether an award for successful and pioneering climate adaptation management can be established, similar to the Federal Environment Ministry's Environmental Management Prize (possibly including an additional category Best Climate Resilience Measure/Best Climate Adaptation Management).

Mainstream climate adaptation in energy and climate partnerships (Wi-0.9): the Federal Government is reviewing how climate adaptation can be more firmly integrated into existing and new energy and climate partnerships with a view to strengthening resilience to the impacts of climate change in partner countries. Increased support for the development of climate-resilient and carbon-neutral supply chains and sales markets will also benefit Germany's internationally interconnected economy.

Improve information about climate risks in international markets (Wi-0.10): possible ways of providing companies with additional information on climate risks in international markets are being explored, with the aim of enabling early adaptation at company level. Germany's foreign trade agency (Germany Trade & Invest, GTAI) can also play an important role here with its existing network of correspondents.

Assess the strength of support for adaptation measures in KfW's programmes (Wi-0.11): in consultation with KfW, a German state-owned investment and development bank, options for strengthening KfW's support for adaptation measures implemented by companies will be reviewed. In addition to supporting investment measures, funding for adaptation plans and vulnerability analyses will also be considered.

3.6.3 Outlook

The following measures will be implemented in the coming years to bridge the current gaps in knowledge that prevent all of the above targets from being fully achieved:

Potential measurability of the targets: there are currently no indicators for measuring progress towards the sub-targets or data on which they are based. Possible indicators must be designed to draw on existing data and existing reporting requirements so that no additional burdens are imposed on companies. In particular, if indicators are based on data from the EU Corporate Sustainability Reporting Directive, it will generally be possible to collect the data through the planned European Single Access Point. Data from a future climate damage estimate for the reference year 2030 are also expected to be available (see also the damage assessment target in the **cross-sectoral action areas** cluster).

Define the adaptation sector and the relevant statistics: the Federal Government will assess the extent to which all economic activities related to climate adaptation can be clearly distinguished and statistically represented as a climate adaptation sector. The aim is to provide a transparent picture of the added value, innovation and jobs in this sector, to be able to chart annual development and take account of the criterion of measurability when defining the adaptation policy targets.

Develop and establish a climate panel: the development of measurable adaptation policy targets in the **economy** cluster is limited by the lack of key information on how companies are affected and on the measures and strategies they implement. Additional reporting requirements are not a suitable way of bridging this information gap while still ensuring an acceptable level of cost and effort. Particularly as aggregating the information from the companies subject to reporting requirements would represent considerable time and effort for the public sector.

An alternative would be to conduct recurring voluntary surveys of companies, which could be used to reliably show developments and also measure progress towards targets. The Federal Government is reviewing whether to establish a panel of companies to address the impacts of climate change and adaptation measures at company level. A climate panel of this kind could also address climate change mitigation issues and thus investigate climate adaptation and climate change mitigation at company level over a longer period for the first time in an integrated approach. As an alternative to setting up a new panel, it must be determined whether issues related to climate adaptation can be included in existing panel surveys of companies (such as the IAB company panel).

3.7 Cross-sectoral action areas cluster

Ministry responsible for the cluster	Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection
Inter-cluster links	**Land and land use** cluster **Human health and care provision** cluster **Urban development, spatial planning and civil protection** cluster **Economy** cluster
Complete cluster paper	see Annex 1 (in German)

3.7.1 Significant risks: why we have to act

In contrast to clusters with a specific focus, the targets of the **cross-sectoral action areas** cluster do not address individual climate impacts and action areas, but rather systemic needs for action and the overall conditions for precautionary adaptation to climate change in Germany.

This cluster therefore sets out targets, indicators and measures that apply across several clusters for cross-sectoral issues. Since not all action needed in the cross-sectoral action area can be underpinned with Federal Government targets at this point in time, individual action fields are outlined in this cluster that cannot be specifically measured (see section 3.8).

3.7.2 Targets, indicators and measures/instruments

The Federal Government will contribute to mitigating the risks in the **cross-sectoral action areas** cluster with the following targets:

Table 12: Targets in the cross-sectoral action areas cluster

Code	Target
Ü-1	By 2030, climate adaptation plans will be available for 80 percent of the municipalities and districts required to do so by the federal states under the Federal Climate Adaptation Act
Ü-2	Federal expenditure on climate adaptation is surveyed every two years starting in 2026; the Federal Government also collects data on the financial losses due to damage caused by extreme weather events
Ü-3	Implement climate adaptation research findings faster
Ü-4	The Federal Government has a national framework with indicators and measures in line with international policy documents and action plans and in accordance with the requirements of the World Heritage Convention so that UNESCO World Heritage sites in Germany can develop climate change mitigation measures and/or climate adaptation strategies or plans (for example, as part of their management plans, disaster risk management plans and framework strategies) by 2030
Ü-5	Adapt federal properties to climate change

Target 1: By 2030, climate adaptation plans will be available for 80 percent of the municipalities and districts required to do so by the federal states under the Federal Climate Adaptation Act

Municipalities and districts are key stakeholders in the implementation of climate adaptation in Germany. There are currently 400 districts and 10,786 municipalities in Germany. According to estimates based on practical experience and media research, around 10 to 15 percent of municipalities and 26 percent of districts have climate adaptation plans. Many plans are also currently in development. The aim here is to contribute to climate adaptation planning at municipal level that is as comprehensive as possible to mitigate current and future climate risks. In addition to

the target set out here, the aim is for an increasing number of municipalities to present climate adaptation plans, even if they are not legally required to do so. This is because, in view of the equivalence of living conditions, people must be equally protected from the risks of climate change, regardless of the respective obligations under federal state law.

The following indicator is used to measure progress: the number of municipalities or districts with a climate adaptation plan that are required to have one by the federal states under the Federal Climate Adaptation Act (Ü-1.a).

The indicator is mainly based on data from the federal states, which are required to report under section 11 of the Act. In addition, the results of the municipal climate adaptation survey commissioned by UBA and from the HUE-4 (cross-sectoral) indicator – "Adaptation to climate change at the municipal level" from the Monitoring Report on the German Strategy for Adaptation to Climate Change and, where applicable, from the SDG indicators for municipalities, for example SDG 13 – climate action – "Municipal climate adaptation index" (no. 86). It will also be reviewed whether information on heat and flood action plans that are potentially included in the adaptation plans can also be captured in future and, if so, how.

Federal measures that will contribute to achieving target 1:

- Climate Adaptation Act (Ü-1.1): with the Climate Adaptation Act, the Federal Government has created a binding framework for precautionary climate adaptation plans that cover as much of Germany as possible
- Funding guideline of the German Strategy for Adaptation to Climate Change "funding of measures for adaptation to the impacts of climate change" (Ü-1.2): with this funding guideline, the Federal Government supports the creation of municipal climate adaptation plans
- Federal advisory, information, networking and training services (Ü-1.3): with many digital advisory, information, networking and training services (including the Centre for Climate Adaptation, the German Climate Action Portal (KLiVO), UBA Klimalots, the DAS Climate and Water Data Service, etc.), the Federal Government provides extensive support for climate adaptation planning in municipalities and districts
- Capacity building and training (Ü-1.4): including training of climate adaptation managers by the Centre for Climate Adaptation, support for staffing capacities for climate adaptation (climate adaptation managers) through existing funding guidelines

Other federal measures that contribute to individual components of climate adaptation plans include recommendations for the creation of heat action plans to protect human health of the Federal/Länder Ad Hoc Working Group on adaptation to the impacts of climate change in the health sector and the heat service of the Federal Health Ministry. Many federal states also support the introduction of municipal climate adaptation management with a wide range of measures.

Target 2: Federal expenditure on climate adaptation is surveyed every two years starting in 2026; the Federal Government also collects data on the financial losses due to damage caused by extreme weather events

To date, federal expenditure on climate adaptation has not been routinely documented. Section 4 (3) of the Climate Adaptation Act requires the Federal Government to regularly collect data on the financial losses due to damage caused by extreme weather events and on the Federal Government's climate adaptation expenditure. The EU is also already collecting data on the Member States' expenditure for climate adaptation measures under Article 19 of the EU Governance Regulation.

The following indicators, which have yet to be developed, will be used to measure progress:

- Federal expenditure on national climate adaptation (Ü-2.a) on the basis of the data collected under the provisions of Section 4 (3) of the Climate Adaptation Act

- Financial losses due to damage caused by extreme weather events (Ü-2.b), based on the data from the climate damage estimate

Federal measures that will contribute to achieving target 2:

- Coordination and standardisation of the methodology for collecting data on federal expenditure (Ü-2.1): the methodology developed as part of an UBA research project will be agreed under the IMAA as the basis for collecting data on federal expenditure and will be applied to the federal budget every two years from 2026. Further development of the methodology in consultation with the IMAA will not be affected.
- Estimate climate change-related damage (Ü-2.2): the methodology and structure for estimating climate-related damage are being developed by UBA. The estimate is intended to systematically assess the damage and costs of damage caused by weather extremes due to climate change.

In addition, the natural hazards portal of the German Weather Service will be set up as a central information source to make this data available to the public.

Target 3: Implement climate adaptation research findings faster

Transferring research results into practice is essential for successful adaptation to climate change. To this end, the Federal Government intends to establish a framework for research funding that will enable relevant research questions to be answered together with the target groups (municipalities, companies, civil society groups and individuals) with the aim of developing needs-driven, practical solutions. In addition, solutions, products and research findings will be brought together so that they can be used and are accessible for the long term.

Sub-target 3.I: Federally funded research will increase the number of research consortia that include the target audience of research findings (such as municipalities, associations and companies) as partners by at least 20 percentage points by 2040 (reference period: 2022-2024)

The aim is to increase the participation of target groups in funded research measures for climate adaptation by means of transdisciplinary research projects. Target groups will be involved as equal partners in the research consortium with their own funding. To continue to allow basic research with an unclear outcome in funding provided by the Federal Ministry of Education and Research, such as model development, this area must account for at least 30 percent of the Federal Ministry of Education and Research's expenditure on research funding.

Sub-target 3.1 is measured using the indicator "Percentage of target groups in research consortia" (Ü-3.1.a). The indicator is determined based on the APA, the Federal Funding Catalogue and other sources if applicable.

Sub-target 3.II: By 2035, the aim is for at least 20 independent products to be transferred from federally funded research into practice

A product[66] can be considered transferred into practice if it is included in the regular consulting portfolio of a climate service provider or another user. To achieve this, the general conditions for research should focus on strengthening transfer phases that go beyond pilot implementation to transfer the developed products. Implementation is supported by best-practice examples, as they

[66] A standalone product can be a website, a guide or similar, or a physical product (for example, the PALM-4U urban climate model, guides and fact sheets on climate-resilient planning of residential areas and buildings).

encourage replication. The compliance of the developed products with relevant laws must be sufficiently addressed where necessary.

The following indicator will be used to measure progress towards target 3.II: number of research products provided by the relevant data and advisory services of the Federal Government, such as the Centre for Climate Adaptation, the Federal Institute for Research on Building, Urban Affairs and Spatial Development, the German Weather Service, the Climate Service Center Germany (GERICS) and the DAS Data Service (Ü-3.2.a). The exact process for providing the products will be decided in consultation with the services and their technical supervisory authorities.

Federal measures that will contribute to achieving target 3: research funding and contract research by the Federal Ministry of Education and Research and ministerial research will be aligned with appropriate measures (for example, funding guidelines) (Ü-3.1). Where useful and appropriate, new funding guidelines for adaptation research will require the participation of target groups and users, and transfer and implementation phases will be integrated into funding guidelines.

In addition to the above-mentioned targets, successful adaptation research also has other aspects that the Federal Government will take into account in its framework, but which are not included in this strategy as measurable targets:

- The legal and technical framework is also crucial to whether or not precautionary measures are effective in preparing for climate change. For this reason, relevant research results need to be incorporated more fully into legislation and technical regulations
- The transdisciplinary nature of research must be strengthened and a transdisciplinary methodology developed
- Climate adaptation needs to be included in as many research areas as possible (mainstreaming)
- The international research dialogue on climate adaptation must also be strengthened outside the EU
- The role of research in climate adaptation needs to be made more visible to the public through targeted communication
- Methods and instruments must be developed that allow for proactive identification and relevance of future issues and how to address them
- The research gaps identified in the current IPCC Assessment Reports and in the KWRA need to be continuously taken into account in federal research funding

Target 4: The Federal Government has a national framework with indicators and measures in line with international policy documents and action plans and in accordance with the requirements of the World Heritage Convention so that UNESCO World Heritage sites in Germany can develop climate change mitigation measures and/or climate adaptation strategies or plans (for example as part of their management plans, disaster risk management plans and framework strategies) by 2030

Background:
UNESCO World Heritage sites play an important role in protecting and preserving the entirety of a country's cultural and natural heritage. Climate change is the greatest threat to the outstanding universal value of World Heritage sites around the world. Internationally relevant documents highlight the acute need for action and define the framework for the responsible national authorities with their targets, expected results and measures.[67] With regard to natural heritage, the IUCN World

[67] The following are of particular relevance here: "Policy Document on climate action for World Heritage" (UNESCO; 2023) https://whc.unesco.org/archive/2023/whc23-24ga-INF8-en.pdf and the Report on the results of the Third Cycle of the Periodic Reporting exercise in Europe and North America.

Heritage Outlook 2020 classifies climate change as a high or very high threat to 33 percent of natural heritage sites worldwide – and the trend is rising sharply.

The UNESCO Policy Document on Climate Action for World Heritage provides the global strategic framework for dealing with climate change in the context of the World Heritage Convention and thus for UNESCO World Heritage sites. It addresses the urgent need for climate adaptation for World Heritage sites, as well as the national and international action level in the World Heritage Convention. It identifies implementation activities for all three levels and highlights direct links to the national climate adaptation strategies. The World Heritage Regional Action Plan for Europe and North America[68] also addresses the issue of climate adaptation in its strategic objectives for World Heritage sites, formulating expected results and measures for implementation.

As a State Party to the Convention, Germany contributes to the implementation of the World Heritage Convention and, together with the relevant national authorities, plays a key role in the adoption, dissemination and implementation of international requirements and recommendations. The federal states (cultural heritage) and the Federal Environment Ministry (natural heritage), along with the environmental ministries at federal state level, are responsible for protecting and preserving the German sites.

There are 54 World Heritage sites in Germany (51 cultural and three natural sites). The most recent report of the German World Heritage Sites as part of the regular reporting process (2022-2023) showed that climate change and its impacts are already affecting the conservation status of German World Heritage sites and will have an increasing impact in future. A 2023 survey by the German Commission for UNESCO of the managers of Germany's World Heritage sites supports this assessment.[69]

The eight German UNESCO Global Geoparks can provide data, experiences and best practices for the development of climate action plans that may also be useful for other geoparks, World Heritage sites and other relevant territorial strategies. They offer practical solutions for climate adaptation as natural carbon sinks, for sustainable land and forest use, use of renewable energy sources, water management, knowledge about land reuse, and offer insights as educational sites to raise awareness about climate change and the need for adaptation measures.

UNESCO World Heritage serves as a role model for the entire national architectural cultural heritage. That is why World Heritage serves as a good basis for deriving best-practice approaches for dealing with architectural cultural heritage and developing relevant measures.

Federal measures that will contribute to achieving target 4:

Consolidation of information and data management (Ü-4-1)

- Expansion and networking of digital information platforms, including publicly accessible data for risk assessment of World Heritage sites; promotion of the use and dissemination of case studies and best practices that are already available through existing international and national platforms and integration of German examples into existing platforms (for example, Panorama Solutions, World Heritage Canopy, UBA Tatenbank, a database of adaptation projects). It is important to prevent duplicate structures from being created here. Past assessment methods and successful experiences in climate adaptation to ensure effective protection against extreme weather events in future. The KERES database[70] already contains the 83 good practice examples

[68] The action plan is available at: https://whc.unesco.org/archive/2024/whc24-46com-10A.Rev-en.pdf.

[69] According to a survey by the German Commission for UNESCO, 51 percent of the World Heritage sites asked see their sites as severely or very severely affected by the impacts of climate change, and 65 percent fear even more adverse effects in future. At the same time, only 14 percent of the sites surveyed currently have a climate adaptation strategy, while 31 percent of the sites are currently in the process of developing one.

[70] https://op.europa.eu/en/publication-detail/-/publication/4bfcf605-2741-11ed-8fa0-01aa75ed71a1/language-en and https://www.imw.fraunhofer.de/de/forschung/wissenstransfer/innovationsakzeptanz/projekte/keres.html

from the EU Open Method of Cooperation report and can be expanded with further examples as needed.

- Distribution of international requirements: ensure accessibility of international and national documents on climate change mitigation and adaptation.
- Inclusion of climate damage estimates in cultural and natural heritage: in the medium term, include monetary and non-monetary damage/losses to World Heritage sites caused by the impacts of climate change/extreme weather as new categories in climate damage estimates.
- Support for the World Heritage sites in collecting data on climate-related hazards, vulnerabilities and risks, as well as other baseline information, and creation of a World Heritage overview map of vulnerability based on the risk information, for example, from the KERES project.[71]
- Support for and promotion of the reciprocal integration of knowledge, data and methods between cultural and climate research.
- Collection, exchange and dissemination of traditional knowledge and technologies for climate adaptation, including in the implementation of the New European Bauhaus; evaluations that review existing research findings, including to intensify dialogue between existing research groups (lessons learned).

Support for climate adaptation measures at the World Heritage sites within the scope of available resources (Ü-4.2)

- Support for the identification and implementation of relevant measures from the respective documents in cooperation with the responsible authorities and World Heritage sites
- Encouragement of the relevant institutions, within the scope of the available resources, to monitor the relevant climate parameters and to contribute to preparing and managing the inevitable uncertainties and complexities associated with climate change through various adaptation strategies
- Promotion of partnerships with relevant authorities and institutions, as well as relevant organisations and interest groups, in activities to develop and implement mitigation strategies
- Development of a process at federal level to network the various stakeholders, to enable a continuous exchange of experiences and to formalise precautionary climate change adaptation
- Promotion of the exchange of experiences and synergies with other UNESCO sites
- Coordination and management of climate adaptation for World Heritage sites within the framework of existing institutions, including through networking, advisory services and support for innovation needs, for the evaluation of experiences and knowledge transfer on the impacts of climate change on the World Heritage site; development of a clearing house procedure at federal level to network the various stakeholders.[72]

[71] See, for example: https://www.sifo.de/sifo/shareddocs/Downloads/files/projektumriss_keres_bf.pdf?__blob=publicationFile&v=1

[72] WHC/23/24.GA/INF.8 Paris, 3 November 2023 https://whc.unesco.org/archive/2023/whc23-24ga-INF8-en.pdf, WHC/24/46.COM/10A.Rev Paris, 10 July 2024 https://whc.unesco.org/archive/2024/whc24-46com-10A.Rev-en.pdf.

Promotion of climate change adaptation measures at World Heritage sites within the scope of available resources (Ü-4.3)

- For example, through existing funding programmes that support climate adaptation measures, but are not directly tailored to climate adaptation measures in the World Heritage site, for example, measures for the protection of the Wadden Sea and ancient beech forests, support for municipalities with World Heritage sites in drawing up and implementing municipal climate adaptation plans as part of funding for the German Strategy for Adaptation to Climate Change, the funding programme of the Federal Ministry for Housing, Urban Development and Building "Adaptation of Urban Spaces to Climate Change", urban development funding programmes and more

Indicators

Progress towards the targets for World Heritage sites and, where relevant, for geoparks, will be measured using the following indicators to be newly developed that will take into account the different overall conditions for cultural and natural heritage sites and geoparks:

- Number of World Heritage sites with an evaluation of climate risks and vulnerabilities for outstanding universal value (Ü-4.a) (to be included as a new indicator in monitoring under the German Strategy for Adaptation to Climate Change)
- Number of geoparks with climate adaptation plans (will be considered for inclusion as a new indicator in the Monitoring Report on the German Strategy for Adaptation to Climate Change) (Ü-4.b)
- Number of World Heritage sites and geoparks in Germany with measures for adaptation to climate change (Ü-4.c) (to be included as a new indicator in the Monitoring Report on the German Strategy for Adaptation to Climate Change)

The 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change already contains impact and response indicators for tourism regions. These will be further developed in cooperation with the World Heritage site managers and municipalities and districts:

- TOU-I-1: Coastal bathing temperatures
- TOU-I-2: Snow cover for winter tourism
- TOU-I-3: Market shares held by wider tourism areas
- TOU-R-1 Seasonality of bed-nights in wider tourism areas

Target 5: Adapt federal properties to climate change

The Federal Government sets itself the aim of adapting civil federal property to the impacts of climate change (see section 7 of the Federal Climate Adaptation Act). Two measurable sub-targets are formulated with reference to this overarching target:

Sub-target 5.I: By 2033, management plans that include climate adaptation measures are in place for 100,000 hectares of federal forestry land

For most of the 115,000 hectares of forest managed by the Forestry Department of the Institute for Federal Real Estate, more diversity also means more resilience, in other words, greater resistance to external influences such as the impacts of climate change. Forestry adaptation measures that take into account the contribution biodiversity makes to maintaining the functional integrity of ecosystems as a prerequisite for forests to provide a wide range of ecological services therefore contribute to long-term climate change mitigation and adaptation.

Management plans serve as the basis for creating climate-adapted forests and adaptive forest management that takes into account environmental dynamics (also with regard to future degree of naturalness). They form part of a medium-term forest management plan that not only includes

measures for the on-site management of forests but also promotes the resilience and biodiversity of forest stands.

The following indicator, which has yet to be developed, will be used to measure progress: hectares of federal forestry land with forest management plans (Ü-5.1.a).

Federal measures that will contribute to achieving sub-target 5.1:

- Creation of forest management plans for 25,000 hectares of federal forestry land per year (Ü-5.1): the Forestry Department of the Institute for Federal Real Estate usually draws up the relevant forest management plans every ten years. The specifications in the Klimaplastischer Bundeswald (Climate-Adapted Federal Forest) project will also apply, taking into account the local conditions and the degree of naturalness of the forest.
- Modelling of locally adapted tree species for all federal forestry land, taking into account future climate scenarios (Ü-5.2): locally adapted tree species are modelled by the Nordwestdeutsche Forstliche Versuchsanstalt, a forest testing station in north-west Germany, on behalf of the Forestry Department of the Institute for Federal Real Estate.
- Modelling of near-natural forest ecosystems under future climate scenarios (Ü-5.3): modelling of near-natural forest ecosystems is based on an expert assessment by the nature conservation unit of the Forestry Department of the Institute for Federal Real Estate.

Sub-target 5.II: By 2027, heavy rain checks are drawn up for 100 percent of civilian properties

The Institute for Federal Real Estate is stepping up precautionary measures for heavy rainfall for its properties. Since 2020, it has been conducting heavy rain checks as a means of assessing civilian properties. Priority has been given to systemically important infrastructure, such as federal police properties.

The federal building authority is taking precautionary measures to protect against heavy rainfall based on the potential risk. This could be, for example, increasing the height of a kerb or buying mobile flood barriers. If the initial assessment finds high potential for damage, a flow pathway and sink analysis or a hydraulic flooding analysis is commissioned.

Progress towards this target will be measured using the following indicator to be newly developed: the number of federal government civilian properties that have undergone heavy rain checks (Ü-5.2.a): a monthly evaluation is carried out by the Institute for Federal Real Estate to monitor progress towards this target up to 2027.

Federal measure that will contribute to achieving sub-target 5.2: possibility of commissioning the federal building authorities to carry out the heavy rain check after setting appropriate priorities (Ü-5.4).

3.7.3 Outlook

Possible options for further developing the target for climate adaptation planning include raising the target to 100 percent, taking into account the status of implementation and setting a target for municipalities and districts that are not required to do so under the Climate Adaptation Act. Long-term research programmes for method development, knowledge management and innovation support can make an important contribution to cultural heritage protection. In addition, the protection of natural and cultural heritage sites must be integrated into the climate impact and risk analysis. Indicators for assessing the impacts of climate change and the progress of risk management must be developed – both for the World Heritage sites and for the survey and accounting method to be used in estimating climate damage to World Heritage sites.

The Federal Government recommends that the federal states offer their own support programmes, where these do not already exist, to create climate adaptation plans at municipal and district level, in

line with the programmes offered by the Federal Government (in particular the Centre for Climate Adaptation). In addition, the Federal Government recommends that the federal states also consider conducting a survey of their respective climate adaptation expenditure on a regular basis. The Federal Government expects the federally funded cultural institutions to develop emergency plans that also address the impacts of climate change, if they do not already have such plans, by the end of 2025 at the latest.

The federal states are a major driver of research, both through their responsibility for colleges and universities and through joint research funding by the federal and federal state governments. To improve climate change adaptation research, including ways to improve the transfer of research findings, the issue needs to be mainstreamed in the research landscape. This means that taking climate adaptation into account in as many research areas as possible will enable results to be transferred more broadly. The federal states can support this process, for example, by helping to establish and fill professorships, setting the research focus of university institutes or submitting research funding applications as part of the Excellence Strategy.

Taking greater account of climate adaptation in norms and standards can help prevent the impacts of climate change in many areas. A study commissioned by UBA (2021) showed a clear need for action in this area and identified starting points for greater consideration. One approach would be for the relevant standardisation bodies to review and, where appropriate, take into account climate adaptation aspects when they regularly review existing standards.

3.8 Additional action areas/fields

In addition to the specific targets mentioned above, the following **action fields** are planned. These include many other activities of the Federal Government that are relevant to comprehensive precautionary measures to address climate change. In contrast to the targets listed under the clusters, no measurable targets are set in the action fields.

3.8.1 Social justice and vulnerable groups in climate adaptation action field

One of the aims of the Climate Adaptation Act is to prevent the increase in social inequalities brought about by the negative impacts of climate change (section 1 (3) of the Climate Adaptation Act). The **social justice and vulnerable groups** action field adopts the qualitative goals of the National Sustainable Development Strategy in the transformation field 1 health and well-being, social participation (known as the TT-1 report).[73] In particular, these are: target 3: good health and well-being, target 5: gender equality and target 10: reduced inequalities, which also apply in the context of the risks of climate change and for a socially just adaptation policy.

Social justice and gender equality are important cross-cutting requirements for good governance in climate adaptation, without a measurable target set at present. In August 2023, the Federal Government adopted comprehensive principles for a socially just transformation towards a sustainable society, which also include climate adaptation. The overarching guiding principle is human well-being. The three most important action fields here are health promotion, active participation for everyone and society's ability to undergo transformative change. For climate adaptation, this triad implies both active support and empowerment at individual level for personal preparedness and the design of suitable institutional, structural and societal framework conditions. Important prerequisites in this context are effective public services and guaranteed equality of opportunity and distribution.[74]

Climate risks: extreme temperatures/heat, heavy rainfall and flooding endanger health, well-being, income opportunities and assets, with risks and capacities for risk prevention and damage limitation distributed unequally across society.

Different vulnerabilities to the dominant risks must be taken into account. Effective protection against the risks of extreme weather events must be developed. The following priorities for cross-ministerial action have been identified as part of the Federal Government's climate adaptation strategy:

1) **Precautionary protection for vulnerable groups** to the impacts of climate change, particularly with respect to health and well-being, the ability to participate and equality in opportunity and distribution. Climate risks for individuals, such as heat stress and flood risk, do not affect everyone equally in all phases of life and across all socio-economic backgrounds. That is why it makes sense to consider long-term risks such as the impacts of climate change from a life cycle perspective,[75] taking the socio-economic situation into account. Particularly sensitive phases of an individual's life, as well as phases that especially benefit from environmental conditions that promote good health, can affect an individual's capacity to adapt. Another important question is whether people in a household residing in a rented property have structural options (for example energy-efficient modernisation for cooler rooms) and the financial resources for household-related adaptation measures. An individual's ability to adapt also increases with **spatial and**

[73] https://www.bundesregierung.de/resource/blob/975274/2215554/5a87a48a8edebaa242f4de1890a39b28/2023-08-23-transformatiosnbericht-menschliches-wohlergehenericht-1--data.pdf?download=1.
[74] see https://www.bundesregierung.de/resource/blob/975274/2215554/5a87a48a8edebaa242f4de1890a39b28/2023-08-23-transformatiosnbericht-menschliches-wohlergehenericht-1--data.pdf?download=1 S. 9 9.
[75] Sachverständigenrat für Umweltfragen 2023: Sondergutachten Umwelt und Gesundheit konsequent zusammen denken S. 39.

temporal flexibility and autonomy.[76] In other words, the possibility of actively preventing heat stress or flooding is an important factor in personal preparedness.[77]

2) **Precautionary protection in particularly vulnerable phases of life**. The focus is on the socially unequal distribution[78] of **negative environmental impacts** (mainly air and noise pollution, insufficient access to blue-green infrastructure, in other words green spaces and water bodies, thermal stress) and **environmental resources** that can reduce exposure and compensate for risks. There are increased requirements for reducing exposure through spatial and nature-based measures, especially for towns and cities.[79] **Urban heat islands** often occur in combination with other environmental stressors (multiple pressures) and primarily affect socially disadvantaged people.[80] The concept of environmental justice represents an approach at municipal level for identifying multiple pressures and minimising these in a targeted manner. The indicator for the accessibility of cooling green spaces (see **urban and settlement development** action area) for the climate adaptation of urban areas is a response to this challenge.

3) Consideration of the **distributional effects of adaptation policy**: the social impact of climate adaptation instruments and measures must be considered in all clusters, and adaptation policy must be designed to be equitable from a social and gender perspective to prevent maladaptation. To implement this target, the Climate Adaptation Act defines a framework that provides for the systematic consideration of climate risks by bodies discharging public functions in accordance with section 8 of the Act. Regular evaluation of progress determines the need for follow-up action.

4) **Procedural justice in climate adaptation policy**. The guiding principle of the 2030 Agenda, leave no one behind (LNOB), is the basis for action – enabling the active and self-determined participation of all people, including through target group-specific participation processes. UBA, the Centre for Climate Adaptation and the network of authorities of the German Strategy for Adaptation to Climate Change, among others, are addressing these methodological issues with research projects, advisory services and best-practice examples.

3.8.2 Occupational health and safety in climate adaptation action field

Climate change is affecting our working environment and can jeopardise the safety and health of employees – and, as a result, company productivity. In Germany, there are longer periods of hot weather, more intense solar radiation, a higher probability of extreme weather events and changes in flora and fauna. These climate change-related shifts are already having an impact on working conditions and will endanger the health of employees if the necessary occupational health and safety measures are not taken in time.

In November 2023, the Federal Ministry of Labour and Social Affairs launched a large-scale participatory process with stakeholders in the area of occupational health and safety. The WORK: SAFE AND HEALTHY programme addresses protection against heat, extreme weather events, new hazardous substances and vectors (such as allergens, mosquitoes and ticks) as well as awareness-raising and compliance over the course of 2024. With a view to employees, effective and practical

[76] Aufterbeck, M et.al. no date given: Soziale Dimensionen von Klimawandelfolgen. Synthese der zentralen Ergebnisse des Projektes. Ed. German Environment Agency (in publication).

[77] [77]Measures for better informing the population can be found in the clusters [civil protection] and [health] and in the action field [personal preparedness]. Targets and measures for the prevention of material damage to buildings can be found in the action area [buildings].

[78] 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change: https://www.umweltbundesamt.de/en/publikationen/2023-monitoring-report-on-the-german-strategy-for.

[79] 2023 Monitoring Report on the German Strategy for Adaptation to Climate Change p. 220 ff.

[80] See for example: social disadvantages still coincide with health-related environmental impacts. People affected by poverty are also more often afflicted by noise, air pollution, climate change and, especially in cities, a lack of green and open spaces. In the context of climate change, the negative impacts will increase, especially in city centres. This is where environmental justice comes in. TT1 Report, p. 13; see SRU 2023 section 2.2.3, p. 39.

health protection at work must continue to be ensured. To achieve this, occupational health and safety must be adapted to the changing climate conditions, and frameworks for fair working conditions must be established. Top priority must be given to protecting the health and safety of employees.

3.8.3 Provision of basic digital data for climate adaptation action field

Climate risk analyses form the basis for the development of climate adaptation strategies and plans at the federal, federal state and municipal levels, as well as for bodies discharging public functions. Nationwide standardised basic data sets on climate trends will ensure coherent basic data and enable comparability of the adaptation strategies and plans developed at different levels. In particular, the German Meteorological Service provides basic climatological data and services digitally through various distribution channels and platforms (such as climate advisory services, the German Climate Atlas, Climate Data Center, climate forecast website, opendata server, etc.). In addition, it issues alerts for impending extreme weather events such as heavy rainfall, storms or heat waves. These alerts are sent over the German Meteorological Service's website and its WarnWetter weather app, among other channels. With the development of the natural hazard portal for Germany, the German Meteorological Service will in future also provide information on the situation and precautionary measures as well as early warnings for a continuously growing number of natural hazards. These will be published in a central location in a standardised and accessible format and will contain all the data needed to understand the information and warnings. The DAS Climate and Water Data Service, which has been available since 2020, is gradually expanding the range of standardised and quality-tested basic data sets and climate services that meet requirements, both for the past (climate monitoring) and for the potential climate future (climate forecasts and climate projections). Four higher federal authorities of the Federal Ministry for Digital and Transport are involved in the DAS Data Service in its current stage of development: German Meteorological Service, the Federal Institute of Hydrology, the Federal Maritime and Hydrographic Agency and the Federal Waterways Engineering and Research Institute. In close cooperation and based on the current state of research (in particular IPCC), the partner authorities develop climatological, hydrological and maritime data products in high spatial resolution and provide a wide range of climate services to various user groups.

Other providers of products and services related to climate change at regional level include the Climate Service Center Germany, the regional climate offices of the Helmholtz Association, the German Climate Computing Centre and climate offices and centres of expertise in the federal states. Following the adoption of the Federal Climate Adaptation Act, it is expected that all public authorities (Federal Government, federal states and municipalities, as well as bodies discharging public functions) will need more climatological, hydrological and oceanographic basic data sets and portfolios that can be used to tailor adaptation measures. To provide data quickly and in the required spatial and temporal resolution, it will be necessary to carry out specialised development work and set up a data delivery system that is also geared to the requirements of the regional and municipal levels. The scientific methods developed to generate the required data products must be put into practice as far as possible so that new scientific findings can be incorporated into the latest climate data for climate risk analyses with maximum resource efficiency.

3.8.4 Personal and financial preparedness action field

For successful climate adaptation in Germany, it is necessary not only for the various stakeholders to work together at all levels of government and in all action areas, but also for the public to participate (personal preparedness). This includes, in particular, precautionary structural measures in buildings

and living environments, precautionary organisational/operational measures during use and operation[81] and financial preparedness, for example through insurance.

Background:

A study on the costs of climate change impacts in Germany (Kosten durch Klimawandelfolgen in Deutschland) commissioned by the Federal Economics Ministry and the Federal Environment Ministry[82] shows that since 2000, damage costs amounting to an average of 6.6 billion euros per year have been incurred in Germany due to natural hazards, totalling at least 145 billion euros in damage costs. In addition to the financial losses, there are the irreversible losses of human life and the difficult task of forecasting future financial burdens on public and private budgets, which, however, are generally trending upwards due to the increasing loss potential from climate change. In 2021, storm Bernd caused record levels of damage in Germany. Around thirty percent of the total damage was insured. Aufbauhilfe 2021, a special fund, was created to compensate for the remaining losses, with up to 30 billion euros available. Of this, 16 billion euros were provided by the Federal Government and 14 billion euros by the federal states. In the context of natural hazards, an increase in insurance density can make a significant contribution to improving the resilience of society and the economy to the impacts of climate change and prevent public budgets from being burdened in the event of damage. However, significant financial relief for public budgets and private households can only be achieved through substantial risk prevention measures that prevent or reduce damage.

Personal preparedness in buildings

Currently, only just over half of all residential buildings in Germany are insured against natural hazards. Achieving greater insurance density throughout Germany and eliminating regional differences in insurance density for residential buildings are desirable aims. At the same time, however, disincentives for individuals to take their own precautionary measures in terms of building and organisation must be prevented.

On 15 June 2023, the Federal Chancellor and the Conference of Minister-Presidents of the federal states passed a resolution to set up a joint Federation-Länder Working Group on natural hazards (BLAG Elementarrisiken) following previous discussions.

The Working Group will examine all options for increasing the prevalence of natural hazard insurance, including compulsory insurance. It will also examine what precautionary measures are necessary, for example in building and environmental law, to reduce the probability of damage occurring in the event of natural disasters, and how the financial risks for public budgets from major disasters can be kept at a manageable level.

At the meeting between the Federal Chancellor and the heads of the federal states on 20 June 2024, the Federal Government reported to the federal states on the results of the discussions of the joint Federation-Länder Working Group on natural hazards and proposed introducing a requirement to take out insurance against natural hazards. The joint Federation-Länder Working Group will continue the discussions.

Personal preparedness in the area of commercial

Extreme weather events also pose a major risk for commercial properties. This should be addressed in the climate adaptation strategy after evaluating the results from the joint Federation-Länder Working Group on natural hazards (need for research).

[81] see also action areas for buildings and civil protection.

[82] https://www.bundesregierung.de/breg-de/schwerpunkte/klimaschutz/kosten-klimawandel-2170246.

Measures:

Construction and organisational measures can be found in the **infrastructure** cluster and in the **civil protection** action area. Financial preparedness measures will be adapted as necessary on the basis of the results of the joint Federation-Länder Working Group on natural hazards (and, following public participation, for the Federal Government's climate adaptation strategy).

Indicators: development of insurance claims (FiW-I-1), risk awareness (FiW-I-2) and claims expenditure for property insurance (BAU-I-5) are captured in the Monitoring Report on the German Strategy for Adaptation to Climate Change.

The insurance density indicator (Bau-R-4) for natural hazard protection for the whole of Germany must increase and in future also be differentiated by federal state.

3.8.5 Education action field

Education and capacity building on the impacts of climate change and on precautionary and adaptation measures in all action fields and areas are important prerequisites for successful planning and practical implementation of specific measures that will be effective in combating future climate change. A lack of skills and a shortage of skilled labour in relevant sectors, such as agriculture, construction and infrastructure, could jeopardise progress towards implementing climate adaptation measures.

In school, vocational and adult education, as well as in non-formal or informal learning environments, there are already some opportunities to learn about climate adaptation. Examples include the educational resources on climate adaptation available on the website www.umwelt-im-unterricht.de, the KlimaCampus digital learning environment for nature-based climate action, and the educational modules on climate adaptation funded by the Federal Environment Ministry. Climate-related resources can also be found in the Education for Sustainable Development and the associated Federal Ministry of Education and Research portal (www.bne-portal.de). To increase knowledge about climate impacts and the necessary measures, and the acceptance of precautionary measures, climate adaptation needs to be more firmly integrated in both formal and informal learning.

At municipal level, the climate adaptation managers funded by the Federal Environment Ministry have created a new professional qualification that is helping to mainstream climate adaptation in municipal structures and tasks. The Centre for Climate Adaptation, for example, offers the further training that is required. Additionally, further education and training in various areas of municipal administration on climate adaptation issues, such as water-smart urban development and blue-green infrastructure, can promote implementation in municipal practice. The Federal Ministry of Education and Research is creating targeted programmes to support the transition to sustainable lifestyles at municipal level as well, by funding educational communities with ESD as a priority topic using ESF Plus funds and with the ESD Competence Centre Education – Sustainability – Municipality (BiNaKom).

In addition to these overarching areas of expertise, specialist knowledge and skills relating to the impacts of climate change and adaptation options in a variety of professional groups, for example in the construction industry, water management, agriculture and forestry or medicine, are an important basis for the sustainable development of the economy and society. With the ESF Plus programme "Sustainability at work – future-oriented training" the Federal Ministry of Education and Research is funding projects for vocational training in sustainable development. The current focus of the programme is on sustainability-related education for the training staff at companies. The aim is to enable them to align their professional activities with sustainability issues and to share the relevant knowledge with their trainees – also with a view to the standard vocational training position of environmental protection and sustainability.

In particular, the formal education system needs to provide more training and continuing professional development on climate adaptation for professionals in occupations with a high potential for implementing climate adaptation measures. This also includes school education, with the aim of improving personal preparedness at an early stage and laying the foundation for skills development for later professional life. Improving working conditions and increasing the appeal of these professions can help to effectively promote young professionals and provide further training in the relevant occupations.

3.8.6 Sport action field

Protecting the health of athletes (amateurs and professionals alike), safeguarding sporting activities and maintaining sports facilities are key elements in the sport action field. Climate change is causing a shift in opportunities for healthy living, as well as health risks for people who play sports or are sports fans. Many athletes who exercise outdoors feel the effects of heavy rainfall, heat and dry periods. Sports facilities can become unusable due to heat or flooding. The conditions for a whole range of sporting activities that depend on snow or sufficient water levels are changing significantly.

Although sport is greatly affected by climate change, there is a lack of systematic analyses and support for climate change mitigation and adaptation measures for the health of athletes and in sports club activities, competitions and events. This is why the Federal Environment Ministry supports the exchange of knowledge and experience through dialogue formats that closely involve sports organisations and other stakeholders. On the basis of a study on health protection and precautionary measures in selected types of sport, insights will be gained and practical recommendations for action for sports organisations and active athletes will be offered. The Federal Institute of Sport Science will also investigate how sports facilities can be designed to be fully climate-resilient in future.

4. Steering, implementation und updates

4.1 Strategy implementation, monitoring, progress measurement and updates

The main provisions for steering, implementing and updating the strategy are stipulated in the Federal Climate Adaptation Act, in particular in sections 3 and 5. The ministerial autonomy principle applies to formulating, reviewing and, if necessary, updating the targets and to identifying, implementing and, if necessary, updating the measures: the federal ministry with lead responsibility for a particular issue is responsible for a target or measure (in consultation with the other federal ministries with relevant remits). The general responsibility for developing, collecting and updating the indicators used to measure progress towards achieving the targets lies with the ministry with lead responsibility for each target (in accordance with the provisions of section 3(5) of the Federal Climate Adaptation Act on the ministerial autonomy principle for targets and measures). Any future departures from this principle must be agreed separately between the respective ministries. The budgetary proviso stated in section 1.1 applies.

To measure the extent to which the targets of this adaptation strategy have been achieved, the targets set out in section 3 are linked to indicators, some of which already exist and some of which still need to be developed or further refined. In future, the indicators will be integrated into the Federal Government's monitoring system, which has been in place since 2009. This is in line with the requirement in section 5 of the Federal Climate Adaptation Act, which stipulates that the Federal Government produce a monitoring report based on the scientific state-of-the-art, to inform the public about the observed impacts of climate change seen in Germany and progress towards achieving the targets.

The monitoring report also forms the scientific basis for evaluating progress towards achieving the targets and for updating the climate adaptation strategy.

The established Monitoring Report on the German Strategy for Adaptation to Climate Change will continue to comprise the following elements after the new indicators for measuring progress towards the targets have been integrated:

- "Impact indicators" (climate change impacts) to describe climate change and climate change impacts with time series in the action areas and clusters. The impact indicators will be largely unaffected by the planned further developments of the monitoring report.
- "Response indicators" (climate adaptation) to describe climate adaptation: the indicators assigned to the measurable targets will be predominantly integrated into the monitoring report as response indicators. The existing response indicators from the current monitoring report (2023) will be reviewed and, if necessary, adjusted or replaced as part of the monitoring report update.

The report will present the indicators in a way that clearly shows which indicators are used to measure progress towards the strategy's targets and which – mostly existing impact indicators – are used to provide general information on the impacts of climate change.

The Monitoring Report will continue to be used as a neutral source of information and as a basis for updating the strategy. Progress towards the targets will not be evaluated in the monitoring report. Instead, as outlined in the Federal Climate Adaptation Act, progress will be assessed by the individual ministries on the basis of the monitoring report as follows when the strategy is updated:

In each case, after the Monitoring Report has been presented, the federal ministry with lead responsibility for each issue decides, in consultation with the other relevant federal ministries, on any changes to measures that may be required on the basis of the available data and information. It may also decide to review and, if necessary, update the targets in its respective area of responsibility.

If monitoring shows that the targets set out in this strategy have not been met, the relevant ministry will adjust the measures and review and, if necessary, update the targets as part of the regular strategy updates. If, on the basis of the monitoring or other findings, a failure to achieve a target is likely, the competent ministry may adopt appropriate measures for improvement even before the climate adaptation strategy is updated.

The responsible ministries' evaluation of progress towards the targets will be set out in the updated climate adaptation strategy. To this end, a separate (sub-)section entitled "Assessment of progress towards the targets" will be added to the next update of the strategy.

For targets where no indicators or data are available in the Monitoring Report (for example, because indicators are still being developed or data has yet to be collected), the strategy update does not yet measure progress using indicators. Even if no indicators or data are yet available for targets in the Monitoring Report, the ministries responsible for the targets in question are free to adjust the relevant measures or review and change the relevant targets as part of the strategy update.

The plan for how the Monitoring Report is presented and further developed will also be updated accordingly. The time series will be updated as far as possible automatically in future in collaboration with existing services and by incorporating the ministries' data. The monitoring data for the German Strategy for Adaptation to Climate Change will be collated in a database operated by the German Environment Agency. The goals of the National Data Strategy and the Open Data Strategy will be included.

The reporting requirements of the EU Governance Regulation and other international reporting requirements on climate adaptation in the context of the UNFCCC stipulate national reporting on the monitoring of climate impacts and adaptation, climate risk assessment, adaptation targets, target achievement and implementation of measures, development at sub-national level and evaluation results. The products related to the Climate Adaptation Strategy, such as the climate risk analysis, the monitoring report, the Adaptation Action Plan and further information and data required to meet reporting requirements and to implement and further develop the German Strategy for Adaptation to Climate Change, will therefore be developed and coordinated as part of a coherent process.

4.2 Outlook

The targets and measures set out for the first time in this strategy will be reviewed every four years and, if necessary, further developed. The next Monitoring Report on the German Strategy for Adaptation to Climate Change is scheduled for publication in 2027. The Federal Government will use this report as a basis for an initial assessment of the target path. In 2028, the next climate risk analysis will also be updated as a basis for strategy development. It will examine the possible future impacts of climate change in Germany, assess the associated climate risks, identify the areas where action is urgently needed and estimate the effectiveness of adaptation options for risk reduction. Both products – the Monitoring Report on the German Strategy for Adaptation to Climate Change and the climate risk analysis – are essential for updating the strategy.

Effective precautionary measures to counter the impacts of climate change are the joint responsibility of the Federal Government, federal states, municipalities and societal stakeholders, and are part of an ongoing process. The Federal Government's strategy provides the framework for a coordinated approach within its area of responsibility and competence. Federal states, municipalities, associations, companies, the scientific community and the general public are called upon to take action within their respective areas of responsibility to protect themselves against the impacts of climate change and to help ensure that the negative effects of climate change are avoided as far as possible and that Germany's resilience to future climate change is strengthened (see section 1 of the Federal Climate Adaptation Act). These stakeholders will continue to be involved in future

updates of this strategy, and their contributions will be incorporated and highlighted to give a comprehensive picture of climate adaptation in Germany.